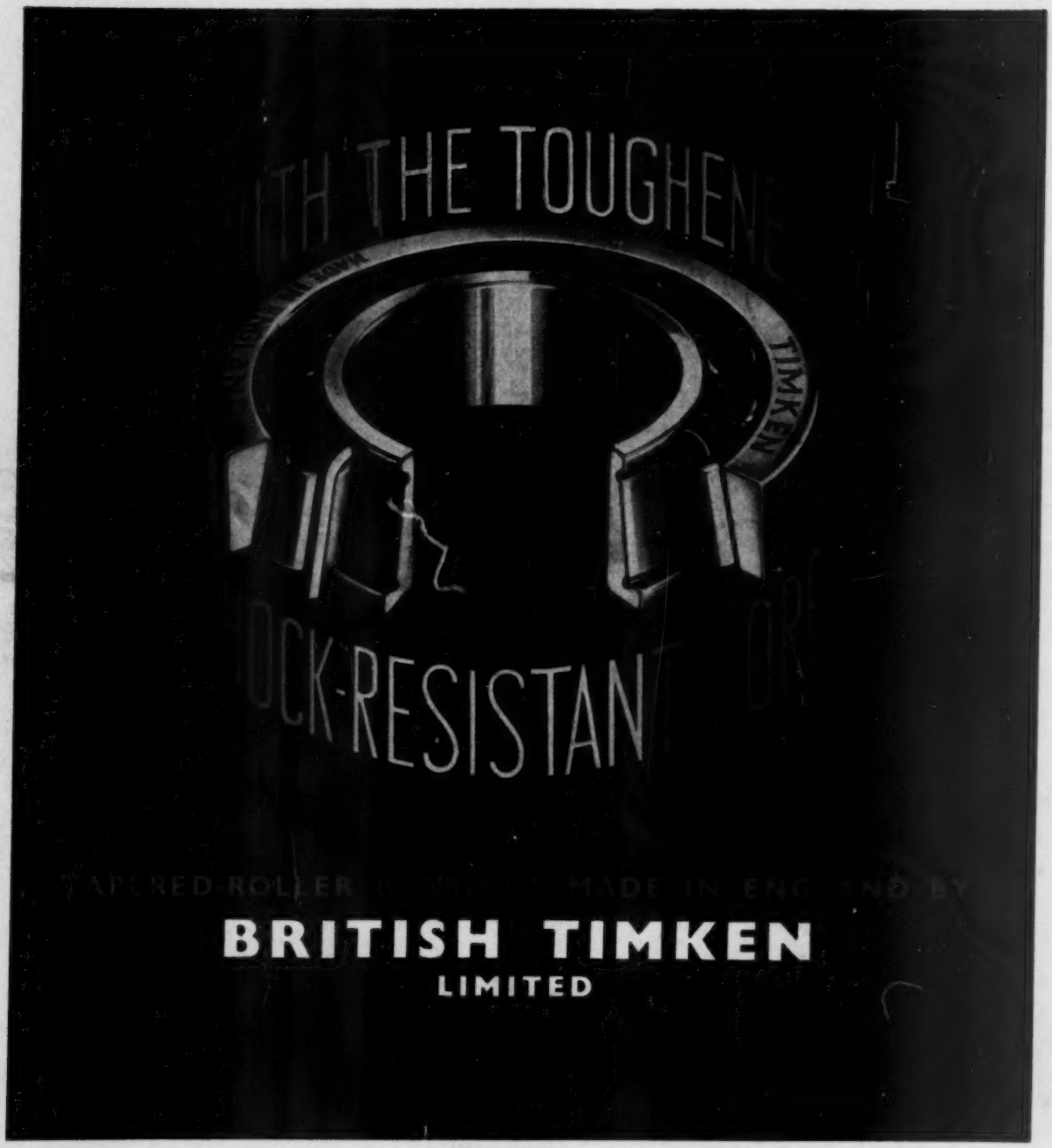
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

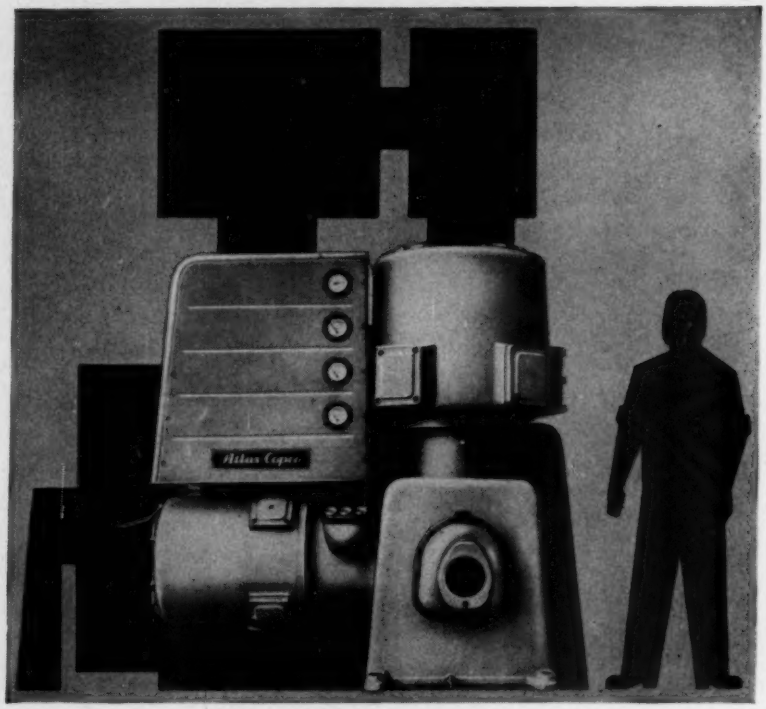
Vol. 49 No. 2 FEBRUARY 1959 PRICE: 3s. 6d.



New Compressor Design

GIVES OUTSTANDING SPACE SAVING WITH REDUCED RUNNING COSTS

The Atlas Copco ER6 is a new stationary compressor which uses fundamental improvements in design to achieve remarkable results in performance and efficiency. The illustration shows the size of the ER6 compared with a conventional compressor of similar output: yet this extraordinary saving in space is achieved with *added* efficiency and economy, and with the same reliability of operation, which has characterised Atlas Copco compressors for 50 years.



PRINCIPAL DATA

Maximum pressure in psi	Speed in rpm	Low-pressure piston displacement in cfm	Free air delivered at 100 psi in cfm	Cooling water required at 60°F approx in galls/hour	Weight in pounds
125	485	1,300	1,075	440	6,600

Economy of operation

The specific power consumption for the ER6 is 10-15% lower than for most machines of this capacity range on the market. At 4,000 hours running time per year this means an *annual power saving of up to* £360.

In addition the cooling water consumption of the ER6 is very low because of the special design of the intercooler, amounting to only 440 gallons per hour at 60°F. This is less than half the quantity needed for the majority of other similar air compressors.

Economy of installation

The ER6 requires an exceptionally small amount of floor space for its capacity. This reduces the cost of foundation and erection, especially with the use of a flange-mounted motor.

Erection and alignment can be simplified by using a base frame which can be delivered as extra equipment. The balance is so good that the ER6 can be mounted on a skid frame, which does not require a concrete foundation. Skid frame mounting is especially advantageous for contractors and makes it possible for the compressors to be moved easily and at low cost from one site to another.

The ER6 is equipped with an oil pressure control device and cooling water gauges together with a full set of instruments for visual control.

A complete range of compressed air equipment

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies or agents in ninety countries throughout the world.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden

C.20-1 G.B.

PIONEER FLUID SEALS

METAL CASED OR METAL INSERT SEALS WITH GARTER SPRINGS

Rotary shaft seals for high speeds. Hair line lip contact and correct spring loading ensure minimum friction loss. Complete range of seals for shaft sizes ¼" to 10" ex stock. Special seal sections for pressure applications.

PRECISION MOULDED 'O' RINGS

All British Standard and pre-standard sizes ex stock in addition to a large number of non standard and American sizes. Pioneer flash free 'O' Rings are ideal for static or slow reciprocating application over a wide range of pressures.

PRECISION GROUND RECTANGULAR SECTION RINGS

Ground to close limits on the outside diameter, Pioneer Rectangular Rings give perfect sealing on high pressure reciprocating applications.

NU-LIP RINGS

A special section Sealing Ring superior to 'O' Rings or Rectangular Rings on low pressure applications up to 600 p.s.i. Cannot roll or twist in the groove. Hair line contact sealing lips ensure low frictional resistance. Interchangeable with British Standard 'O' Ring sizes.

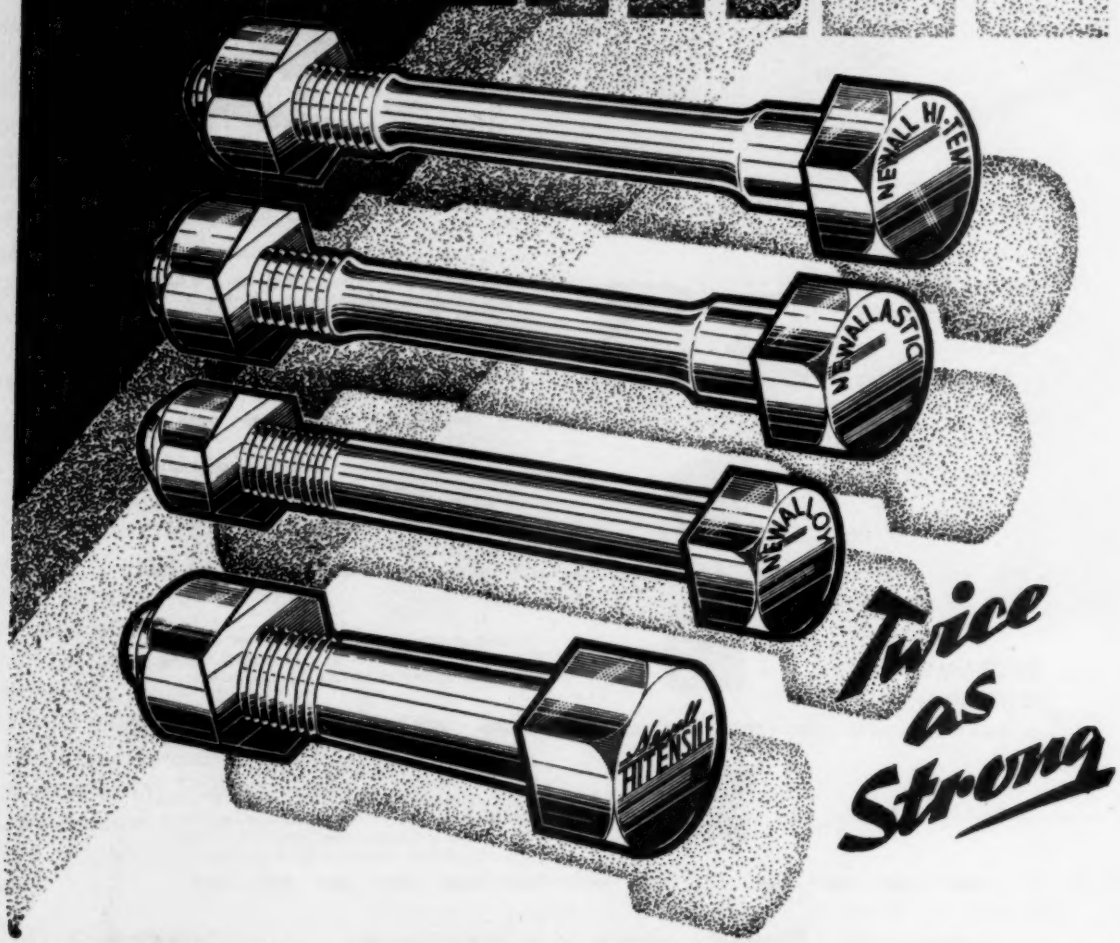
HYDRAULIC PACKINGS & WIPER SEALS

Used as hydraulic and pneumatic Piston Seals, hydraulic cylinder or valve stem packings. Pressures up to 1,500 p.s.i. Six types are available in a wide range of sizes.

Pioneer Oilsealing & Moulding Co. Ltd.

COTTONTREE WORKS, COLNE, LANCASHIRE. TELEPHONE: WYCOLLER 471 (8 lines)

NEWALL



Twice as Strong

NEWALL BRANDED BOLTS

Newall Hitensile . . . Newalloy . . . Newallastic . . . Newall Hi-tem . . .

are recognised by engineers as having unique qualities. We shall be happy to supply any engineer designer who is interested with details of the various bolts and studs, which cover the full range of modern requirements.

A.P. NEWALL & CO., LTD. POSSILPARK GLASGOW N2

Standard or Special!

ARCHDALE

FOR HIGH PRODUCTION

The Standard Motor Co. Ltd., Coventry, is only one of scores of factories where ARCHDALE special drilling and milling machines, as well as automatic transfer lines, are contributing to reduced costs, improved output and quality.

If you are producing components on a large scale, involving drilling, milling, tapping, boring or spot-facing, or any combination of these operations, ARCHDALE can certainly show you the way to lower costs.

We shall be pleased to submit complete schemes for your consideration. Get in touch with us.

JAMES ARCHDALE & CO., LTD. LEDSAM STREET, BIRMINGHAM, 16.

TELEPHONE: EDGbaston 2276 A Member of the Staveley Coal & Iron Co. Ltd. Group

SOLE AGENTS: ALFRED HERBERT LTD., COVENTRY. Telephone: 89221

"Assure me, dearest Matilda, it was all an evil dream"

"Oh villainy most vile!" With this wild eldritch cry Egbert started from his pillows. Matilda, hurrying to his side, pleaded with him to disclose the cause of such piteous perturbation.

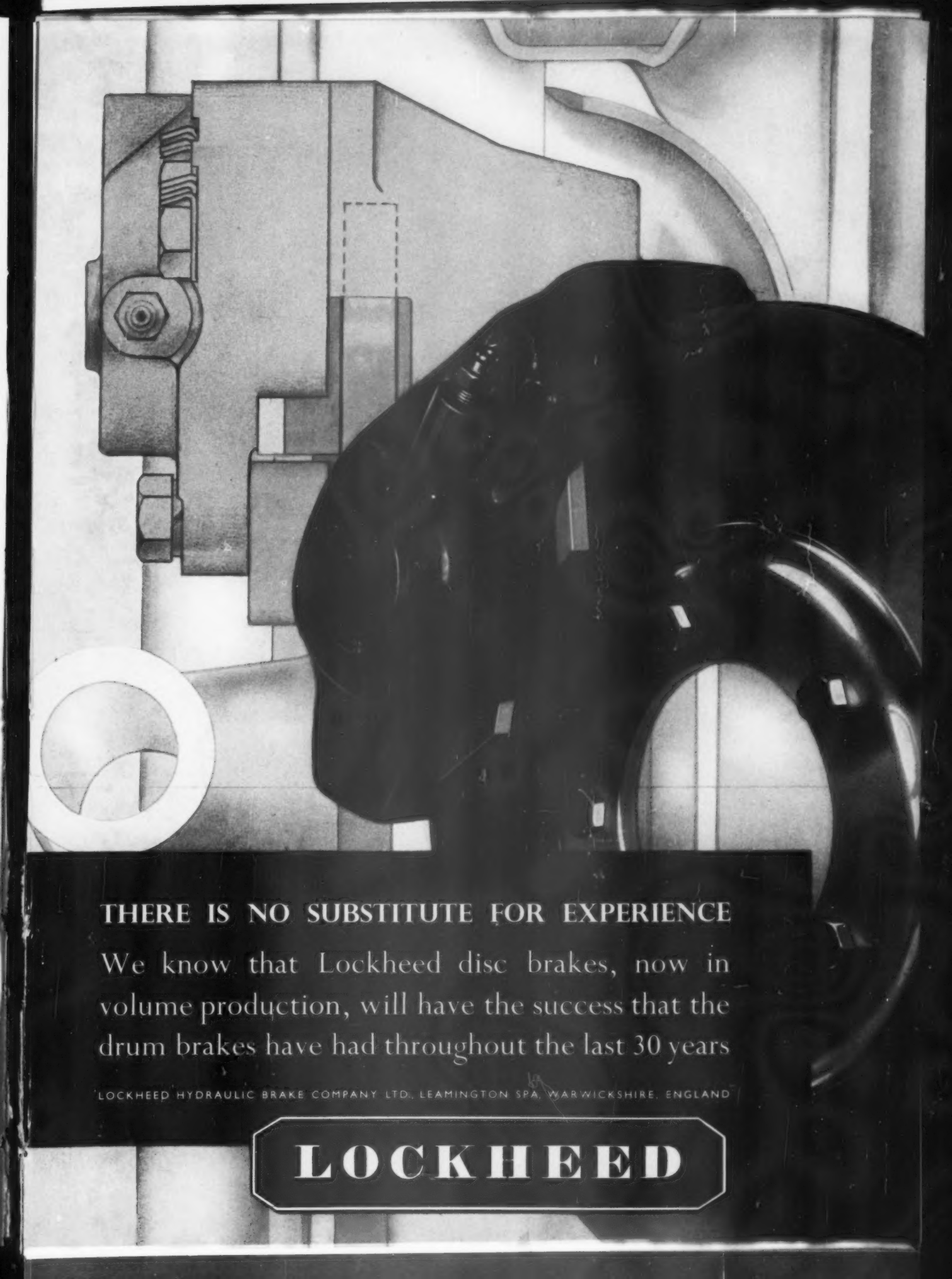
At length, with many a sigh and groan, Egbert gasped, "Driving upon a dark and lonely road, I was of a sudden set upon by footpads and thieves who seized me, hurled me viciously into the roadway and drove off with joyous laughter, mindless of my plight. Even now those dastardly wights are reaping the fruits of my labours, enjoying my engine's surging power as it makes mock of the direst hill, burning away my precious fluid!" *Overcome with anguish, he could say no more. "Courage, my brave Egbert!" Matilda resolutely entreated him. "You are here, in your own bed, Egbert. You have but dreamt this calamity."

Hope battled with despair in Egbert's face. Clutching her hand in his troubled grasp, he breathed, "Assure me yet again, dearest Matilda, assure me it was all an evil dream."

BP DERV

*** The finest quality Derv—BP Derv—is available at Agency sites throughout Britain. With a Shell and BP Derv Agency card your drivers can fill up with BP Derv on credit or for cash at agency rates. The sign on the right is the sign they should look for.**

PETROL AGENCY DERV



THERE IS NO SUBSTITUTE FOR EXPERIENCE

We know that Lockheed disc brakes, now in volume production, will have the success that the drum brakes have had throughout the last 30 years

LOCKHEED HYDRAULIC BRAKE COMPANY LTD., LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

LOCKHEED

A COMPLE

MICRONIC AIR FILTERS

Purolator Micronic Air Filters are of the dry type and are unsurpassed in efficiency and reliability.

The advantages of these filters are as follows:

POSITIVE FILTRATION

All the air consumed by the engine must pass through the filter and the filter efficiency is not affected by the engine speed.

INSTALLATION ADAPTABILITY

The filter, being a dry type, can be mounted in any position and since no oil is used there is no danger of "spill-over".

LOW RESTRICTION

Negligible restriction is offered to the flow of air, ensuring long running periods before servicing is necessary.

MICRONIC PUR

TE RANGE

EASIER MAINTENANCE

Engine vibration assists in removing the accumulated dust from the element. A jet of air directed through the element from the inside is all that is required for normal servicing.

REDUCED RUNNING COSTS

Engine wear is considerably reduced and this together with the simplicity of servicing considerably reduces running costs.

CONFORMS TO BRITISH STANDARDS

The Purolator dry type air filter has been developed and tested to conform to British Standard Specifications.

The illustrations show examples from the range of air filters and breather filters of nominal capacities up to 550 C.F.M.

AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA
WARWICKSHIRE • ENGLAND

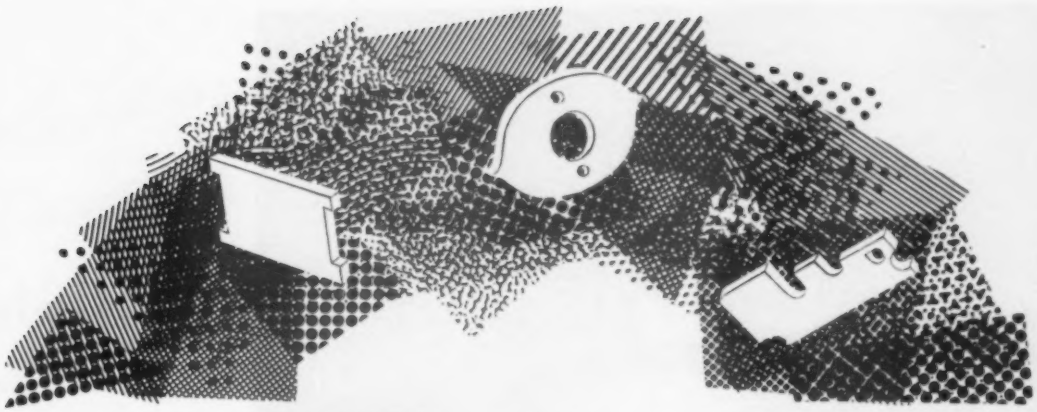
LATOR FILTERS

Regd. Trade Marks: Purolator, 'Mi:ronic'

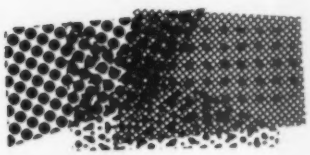
CARS AND THEIR CLUTCHES: STANDARD VANGUARD III

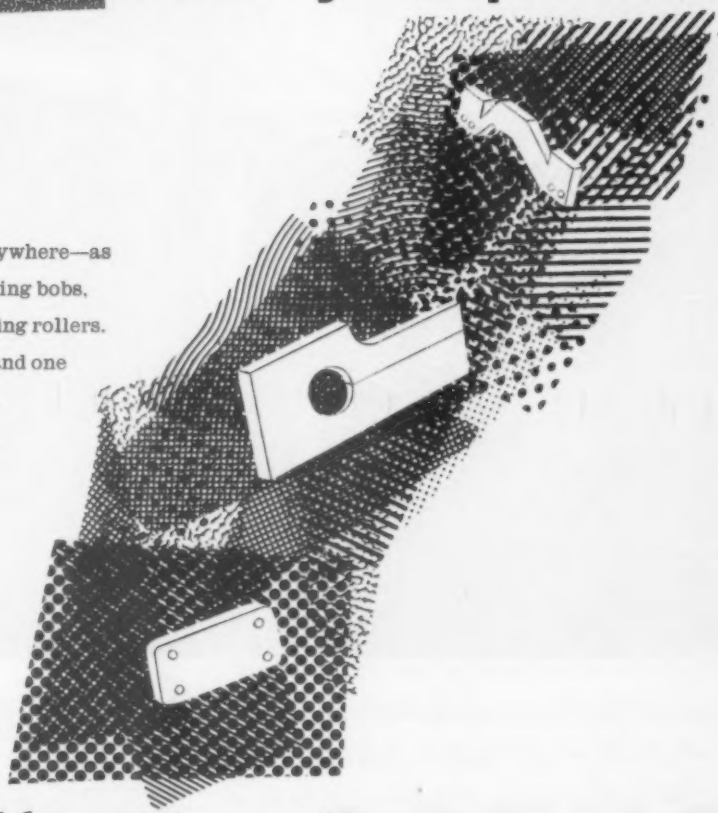
The
BORG
&
BECK
REGD. TRADE MARK
9″ clutch

BORG & BECK COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND



Let BURY FELT solve your problem





You'll find Bury Felt everywhere—as washers, seals and gaskets, polishing bobs, anti-vibration bases and buffing rollers. These are only a few of its hundred and one uses. You will think of many more. For Bury Felt is what you make of it; it can be chiselled, punched, machined or die-cut to suit your needs and is available in many types and textures.

Versatile stuff—

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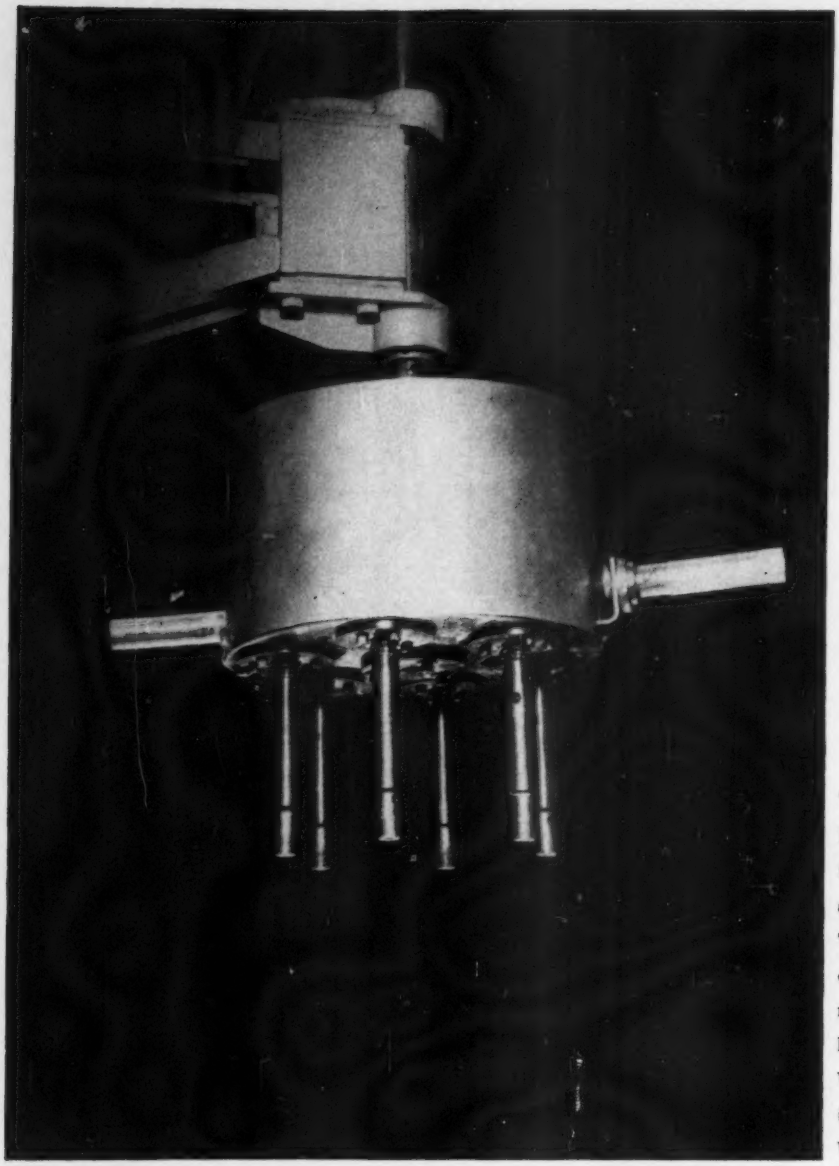
BURY FELT MANUFACTURING COMPANY LIMITED,
P.O. BOX 14, HUDCAR MILLS, BURY, LANCASHIRE
Phone: BURY 2262 (6 lines)
London Offices: 3 Snow Hill, EC1.
Phone: CENtral 4448

BURY FELT

Also manufacturers of
'FOAMBURY' Plastic Foam products



This pneumatic multiple nutrunner has now been running continuously for *four years* on the engine assembly line at Vauxhall Motors. To date, these little horses have dealt with something like half a million units and in all this time have never required attention. Wonderful, you say? Well, of course it's wonderful.
Who made it? Well, I ask you!!!

GUESS WHO MADE IT?

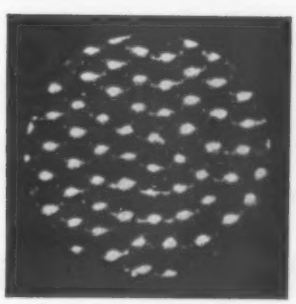
CRC 312

rigid-accurate bronze filters

graded for use with

liquids and gases

Many years' experience in powder metallurgy has resulted in the development by BOUND BROOK of a porous material for the filtering of liquids and gases. It is produced from spherical metal powders of *closely controlled particle size* to give a rigid porous bronze structure of *uniform pore dimensions*. This metallic structure has excellent resistance to impact, is suitable for high pressure filtration in both directions of flow, and enjoys an almost indefinite life. The material is easily cleaned either by washing or by reversing the flow. Designed for such applications as Filter Elements, Flow Control Devices, Flame traps etc., Bound Brook bronze filters are available in six grades to suit required conditions, and in the form of discs, plates, cones, hollow cylinders etc. Special shapes can be made to suit customers' requirements. For further information send for leaflet "BOUND BROOK Bronze Filters".



This microphotograph shows a section of a Bound Brook Filter. Note the porous structure formed by the use of spherical metal powder.

A MEMBER OF THE BIRFIELD GROUP

Bound Brook Bearings Limited

Trent Valley Trading Estate, Lichfield, Staffordshire

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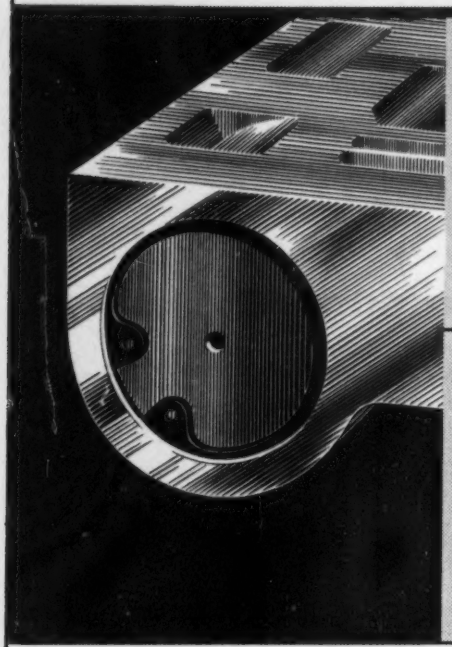
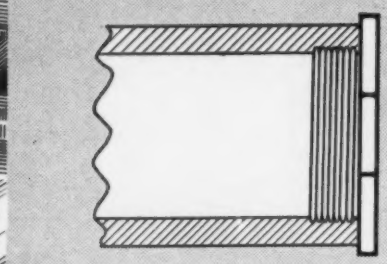
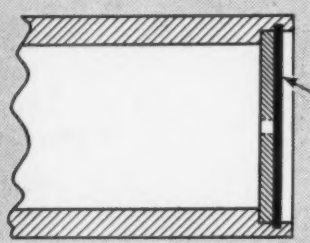
The logical advance in Retaining





OLD WAY

This fluid seal involved internal threading of the tube, which was sealed with an expensive cap-nut. The assembly was laborious and spanners were needed.



THE SALTER WAY

The tube is recessed and then simply grooved with the SALTER Grooving Tool. A Circlip is snapped into position and secures the fluid retaining plate with positive, vibration-free locking. When necessary the Circlip can be removed quickly and easily.

save material–reduce assembly time – cut costs

When it's a question of assembling components in any engineering field, Salter Retainers are the answer. They replace nuts and bolts, screws, cotter pins, and eliminate expensive threading and machining operations. A large standard range is at your immediate disposal, and we should welcome the opportunity to assist in developing special retainers to solve your problems.

Send for the Salter Retainer catalogue — no designer is complete without it.

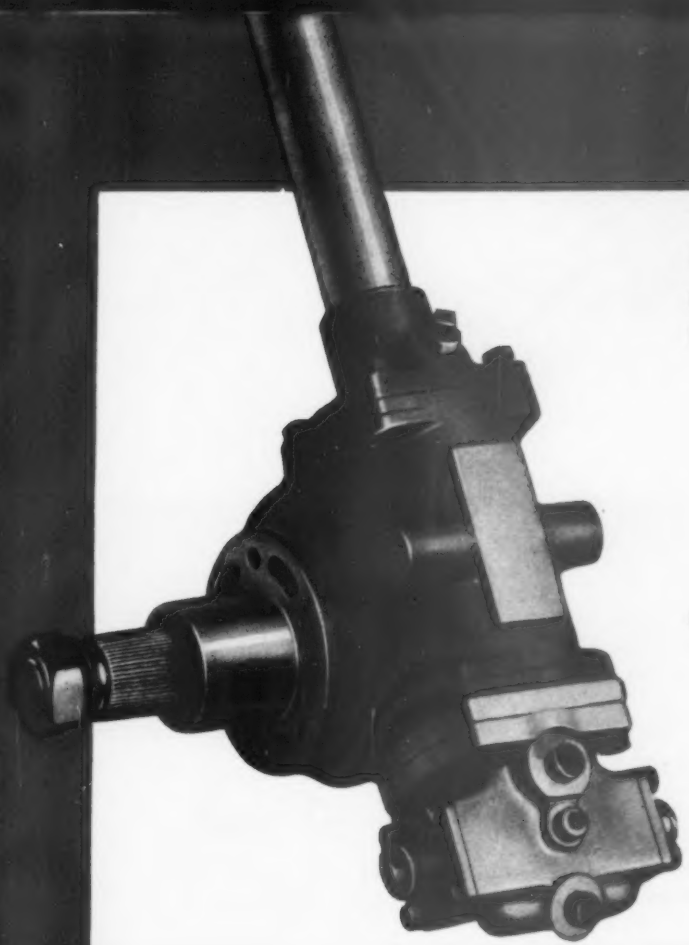
NEATER – MORE POSITIVE – PERMANENT RETAINING

SALTER "TRUARC"

Circlips · Fasteners · Retainers · Fixes

Geo. Salter & Co. Ltd., West Bromwich · Spring Specialists since 1760

H-W.448



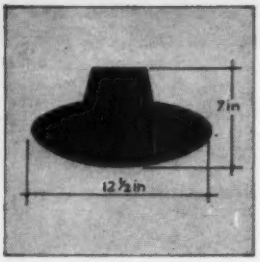
Interchangeable, on the same mounting, with the standard Marles manual gear unit.

THE TYPE 3 'UNIVERSAL' UNIT

Illustrated above is the Type 3 'Universal' steering gear which incorporates the hydraulic control valves mounted upon our type '861' manual gear. This is for use with a separate power pump and with power cylinders operating on the steering linkage. Further particulars will be sent on request.

ADAMANT ENGINEERING CO. LTD.,
THE AERODROME, WOODLEY, Near READING.
Sole proprietors of the Marles Steering Company Ltd.
Telephone: Sonning 2351 Telegrams: Adamant, Reading

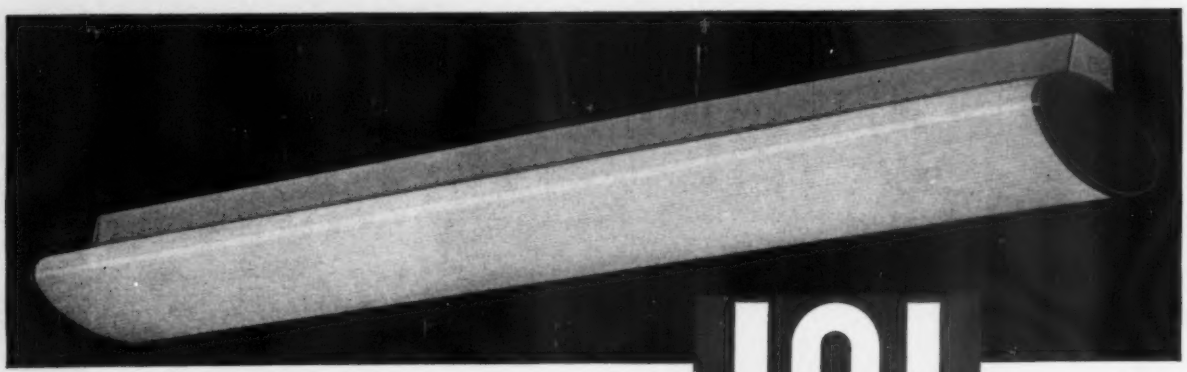
MARLES



one of many decorative designs

The brilliantly successful G.E.C. 101 range of fluorescent fittings offers a wide choice of designs for every lighting requirement — in executive offices, showrooms, shops and stores, as well as factory areas. They are made for 1½ to 8 ft. single or twin Osram guaranteed tubes, and all employ the famous G.E.C. Basic Channel with its proven advantages of versatility and economy in installation and maintenance.

The fitting illustrated F41124/5 consists of a standard channel with an enclosed diffuser in reeded 030 'Perspex' with black ends and polished brass trim.

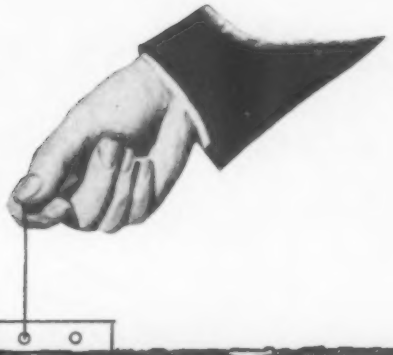


101 range

fluorescent lighting fittings

G.E.C.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2



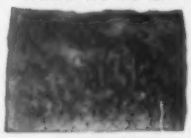
An improved neoprene
for quick-setting adhesive cements

New Du Pont neoprene for better colour and viscosity stability

Du Pont neoprene for adhesive cements offers a lighter original colour. Solutions in suitable solvent systems are essentially water white. Little colour change results when aged at moderately high temperatures. (See pictures at right showing gum stocks.) Adhesive cements made with this new type neoprene, whether compounded or uncompounded, may safely be stored or shipped in metal containers without risk of changing colour.

Greater solution viscosity stability of neoprene, aged at 70°C., is also apparent from results of laboratory tests explained in an 8-page report (No. 58-1). Ask your Du Pont distributor for a copy of it, or write to us. Send also for latest copy of Du Pont Elastomers Notebook containing other information about new developments with Du Pont synthetic rubbers.

COLOUR STABILITY OF NEOPRENE AGED AT 70°C



Original

Two Days

Four Days

Eight Days

Distributors:
Du Pont Company (United Kingdom) Limited,
76 Jermyn Street, London, S.W.1.

DU PONT NEOPRENE

DU PONT
REG. U.S. PAT. OFF.

Better Things for Better Living
. . . *Through Chemistry*

Du Pont Company (United Kingdom) Ltd.,
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Please send me:

( ) Neoprene Adhesive Report 58-1
( ) Elastomers Notebook

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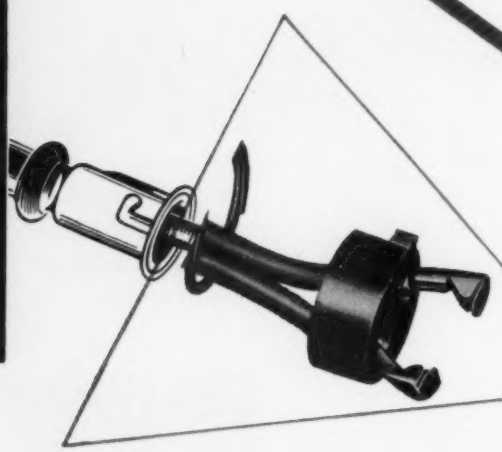
*A-MP modern solderless terminations

for every automotive application

Wherever there is a wire there is an ***A-MP** Solderless Terminal to connect it.

- Top electrical and mechanical performance.
- The pressure-crimp eliminates the necessity for soldering and welding.
- ***A-MP** automatic machines stamp up to 4000 uniform terminations per hour.
- World-wide adoption by leading car and truck manufacturers.



This ***A-MP** solderless Button Contact, specially designed for automotive light sockets is made in strip terminal form and supplied on reels for automatic machine application. High-speed automated terminations ensure uniform high quality and reduce costs.

*A-MP TRADE MARK

AIRCRAFT-MARINE PRODUCTS (GT. BRITAIN) LTD.

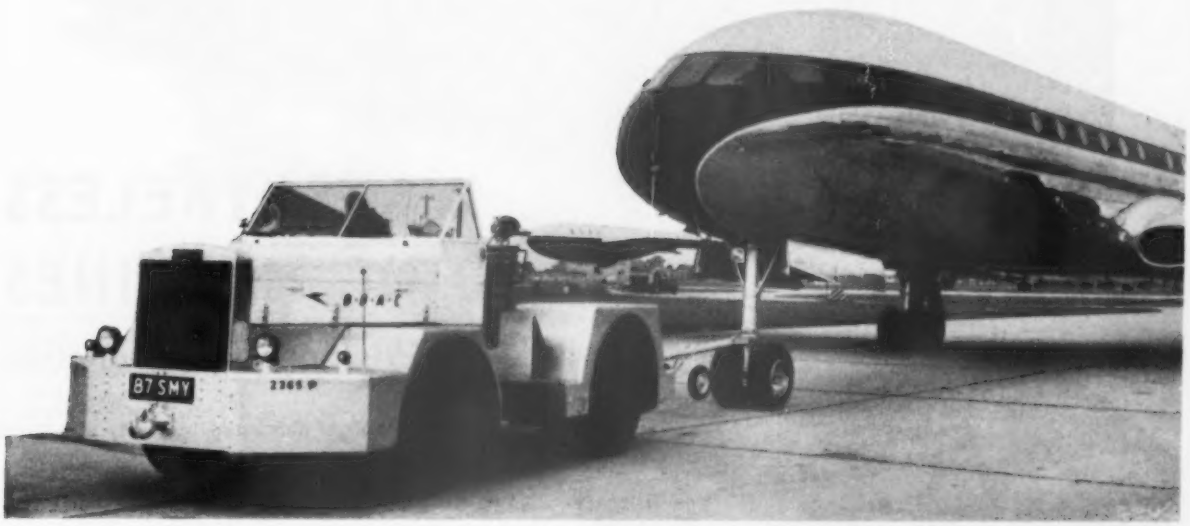
London Office: DEPT. 12, 60 KINGLY STREET, LONDON, W.1. Telephone: REGENT 2517-8 and 3681-2-3

Works: SCOTTISH INDUSTRIAL ESTATES, PORT GLASGOW, SCOTLAND

*Trade Mark of AMP Incorporated, U.S.A.

AP 323-49

KIRKSTALL AXLES



MERCURY AIRTUG

WITH KIRKSTALL AXLES
MOVES THE COMET 4

KIRKSTALL FORGE ENGINEERING LIMITED

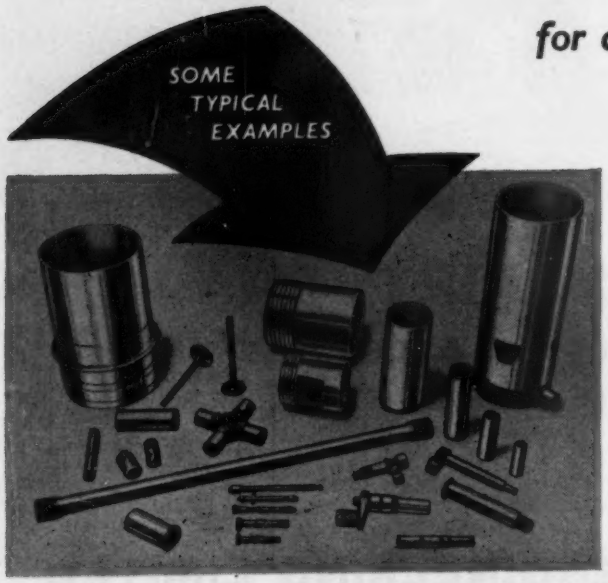
LEEDS 5, ENGLAND

TEL: HORSFORTH 2821 (8 LINES)
CABLE: FORGE, KIRKSTALL

LIDKOPING

CENTRELESS GRINDING MACHINES

for accurate, high-output production



The type 4B machine illustrated is widely employed for production of automobile components and is also a popular machine for the electrical and textile industries, in fact, wherever high output, close tolerance centreless grinding is required.

The grinding and regulating spindles are supported at both ends in super-precision roller bearings of equal resistance and the grinding wheel spindle drive is through a torsion bar to relieve the spindle of belt tension. The range of work diameters which can be ground on the 4B machine is 0.04 in.—6 in. and maximum length for infeed work is 11.8 in.

Write to-day for full details of the Lidkoping range of centreless grinding machines.

Sales & Service for . . . **DRUMMOND-ASQUITH** *. . . the British Isles*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM

'Phone: Midland 3431 (7 lines) Grams: Maxishape, Birmingham. Also at LONDON: 'Phone: Trafalgar 7224 (5 lines) and GLASGOW: 'Phone Central 0922

IF 322

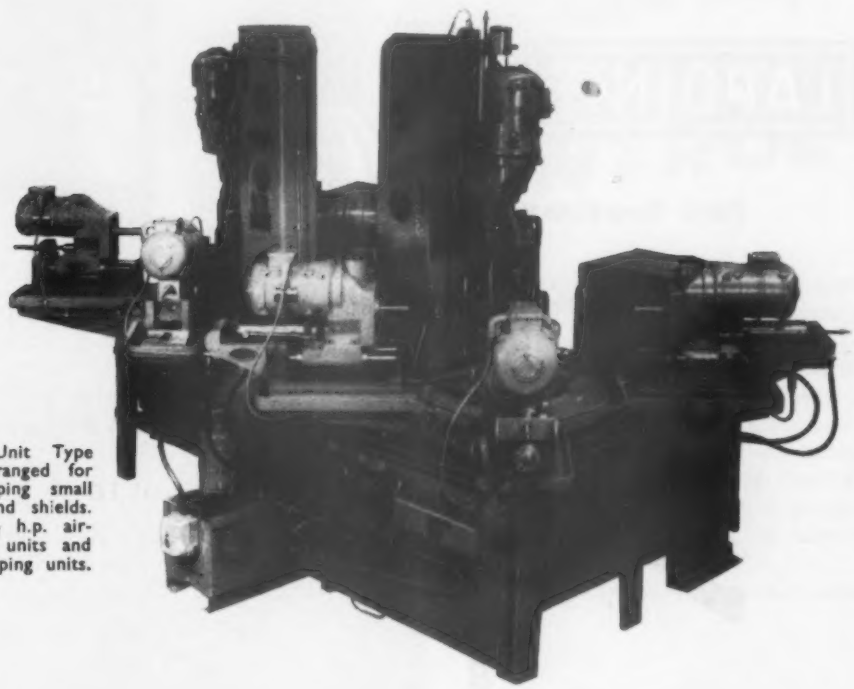
ASQUITH

UNIT TYPE MACHINES

fully engineered for high-output production

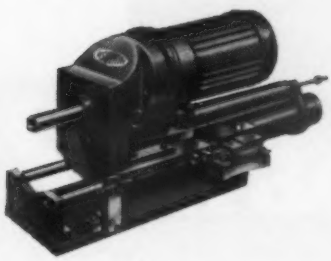
Asquith Units from ½ h.p. upwards can be arranged as individual, multi-way, rotary transfer and in-line transfer machines for fast, automatic production. Some of the unit heads available are shown below. If you require large-quantity production of components at present produced on several machines, it will be worth investigating the possibility of machining them on an Asquith Unit Type Machine, Write today for details of the range of unit equipment or ask for a specialist to discuss your problem.

WILLIAM ASQUITH LTD.
HALIFAX · ENGLAND

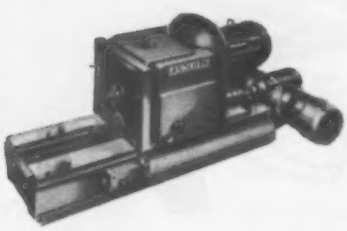


These Asquith Unit Type Machines are arranged for drilling and tapping small electric motor end shields. It incorporates ½ h.p. air-hydraulic drilling units and ½ h.p. screw tapping units.

½ h.p. AIR HYDRAULIC DRILLING UNIT



3/5 h.p. SCREW FEED UNIT



HORIZONTAL STATIC MILLING UNIT

Sales & Service for . . . **DRUMMOND-ASQUITH** *. . . the British Isles*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM

'Phone: Midland 3431 (7 lines) Grams: Maxishape, Birmingham. Also at LONDON: 'Phone: Trafalgar 7224 (5 lines) and GLASGOW: 'Phone Central 0922

A 313

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LAPOINTE

for better

broaching

Broaching round holes in cross members.

Capacity: 2½/15 tons, stroke: 24/30/36 inches. These machines can be supplied for push, pull or surface broaching.

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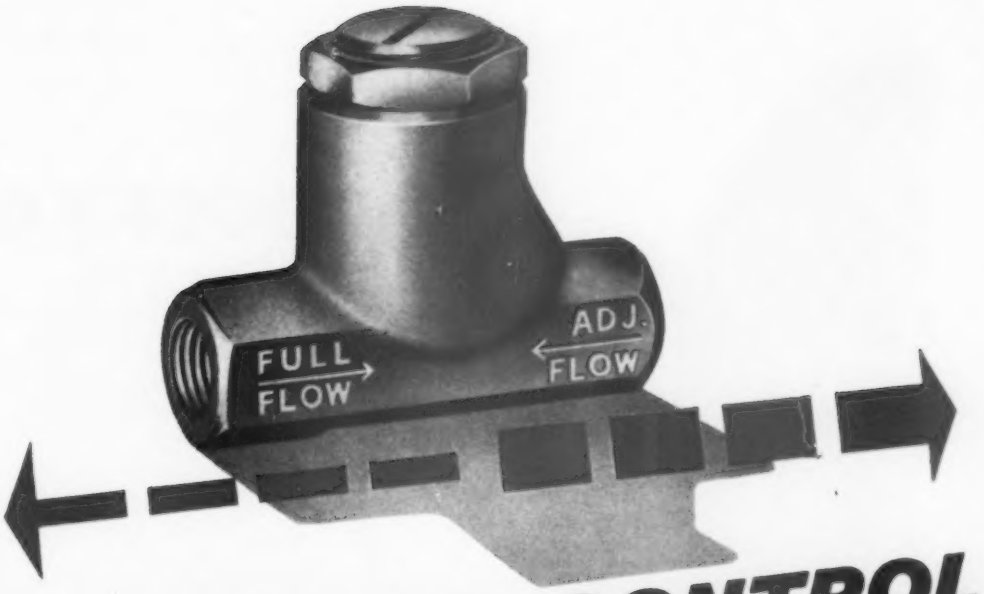

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SCHRADER FLOW CONTROL VALVES provide a control of movement speed so essential to the effective use of compressed air equipment. The range of valves has now been extended to give even greater flexibility.

The valve is easily set, by means of an adjustment screw, thus determining how fast the air flows in the "adjusted" direction. If used in conjunction with an air cylinder, for instance, the valve can control the pressure build-up and with it the *speed* of the piston thrust, but not its pushing force. This controlled thrust speed avoids the impact shock of suddenly applied air pressure, yet permits full thrust force. When the valve is operating in the "full flow" direction a poppet is opened, giving open line pressure. Where controlled air flow is required in both directions, two valves can be fitted back-to-back.

Although designed primarily for air control, these valves are equally suitable for use with oil or water in hydraulic systems.

Body of cast brass.
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Substantial lock-nut resists vibration.

The ¼" bore valve is the latest addition to the Schrader range, which now covers ¼", ⅜" and ½" B.S.P. sizes. These provide a pressure range as follows :—AIR : 0-400 P.S.I. OIL or WATER : 0-800 P.S.I.

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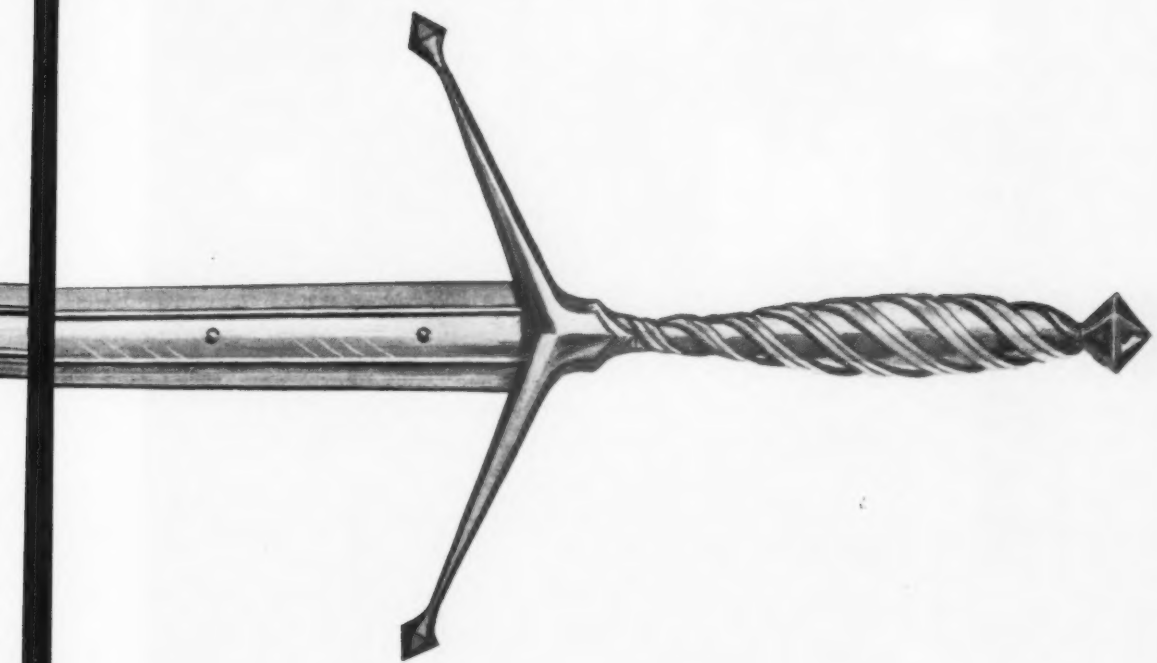

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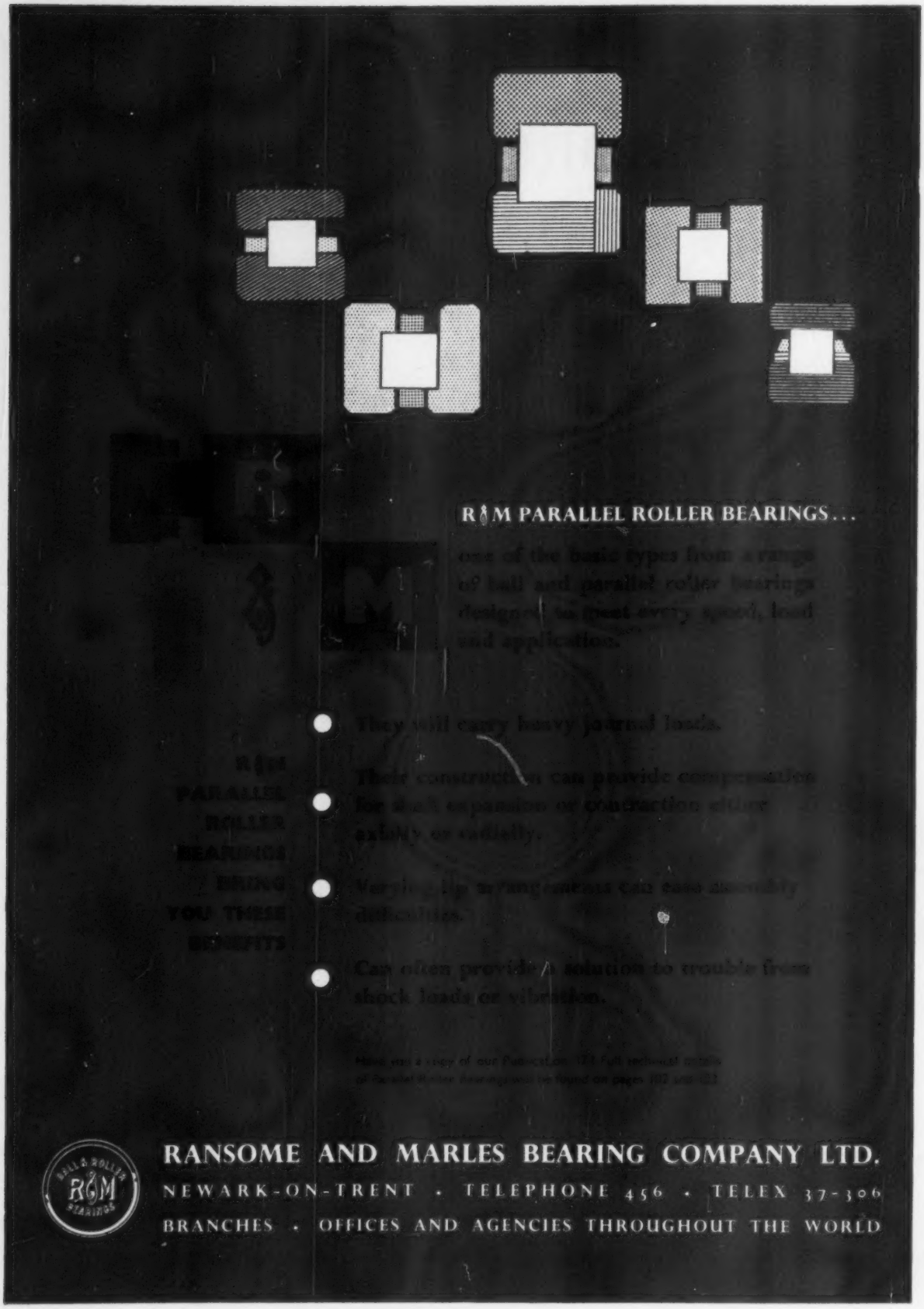
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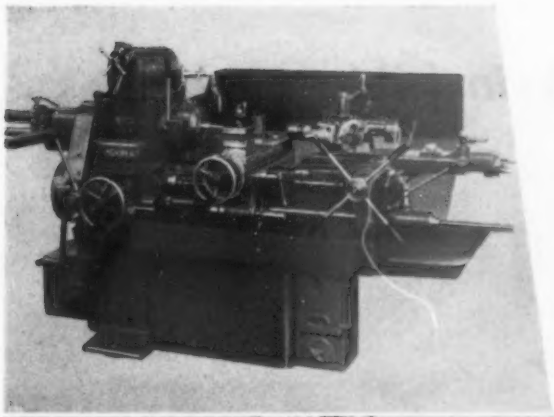

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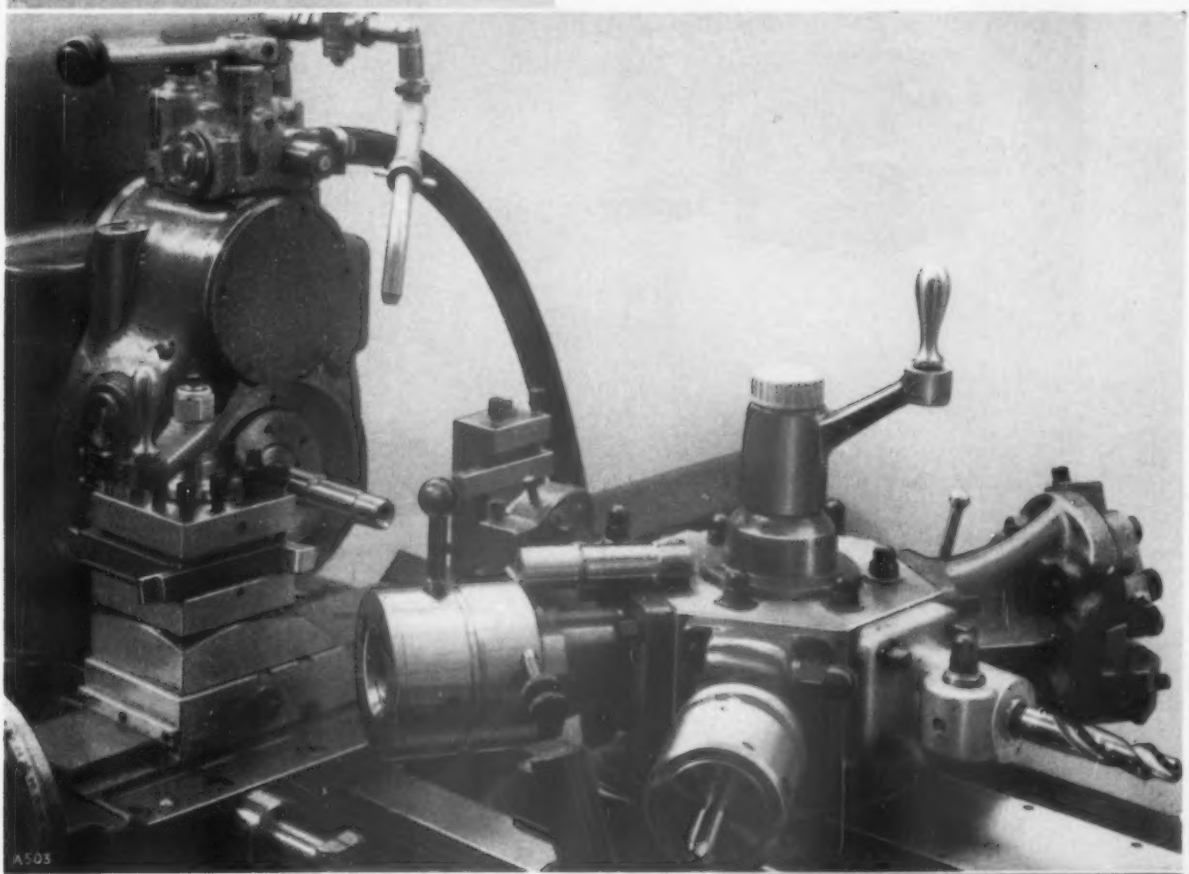
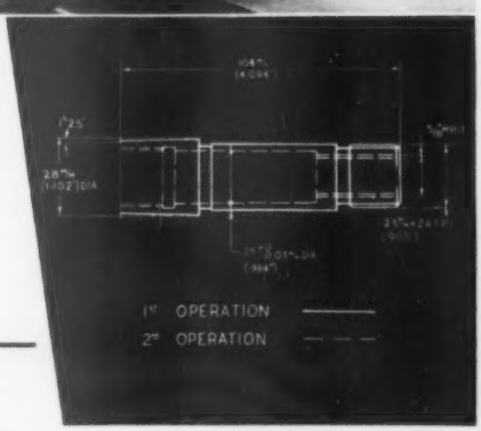


The component shown is machined from 35 tons tensile steel bar on a Herbert 2D Capstan Lathe. The illustration shows the tooling arrangement for the first operation which is completed in a time of 5 mins.



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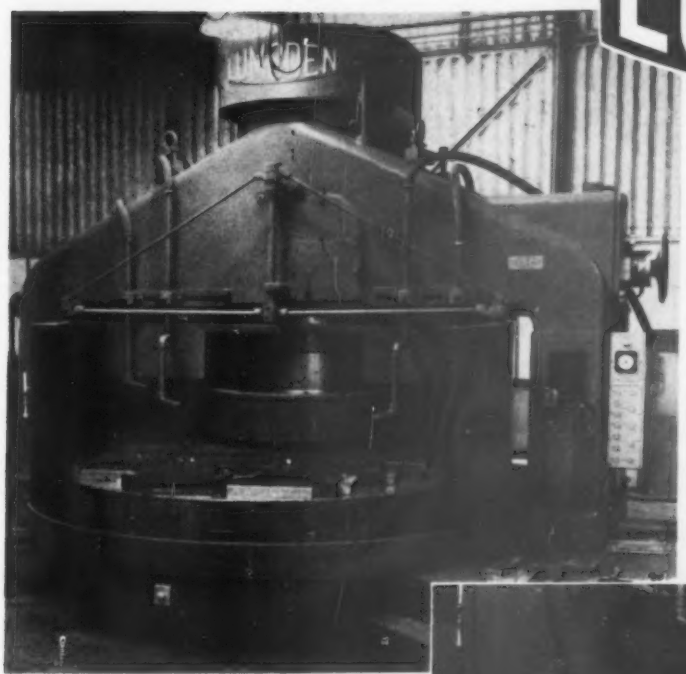
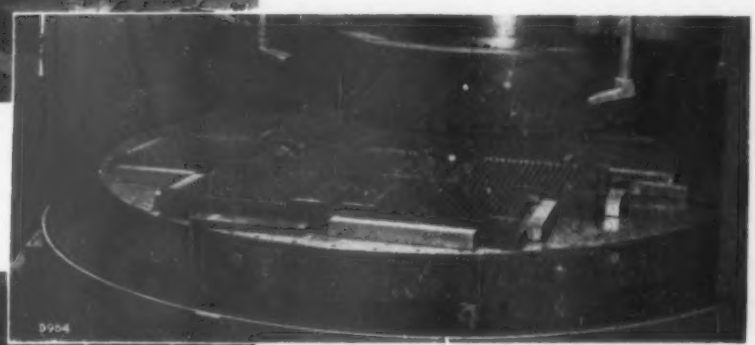
LUMSDEN

surface grinders and cut machining times.



A 100" diameter table machine installed in a customers works to grind a range of cast-iron boiler components, has effected time savings ranging from 50-80% over the previous methods.



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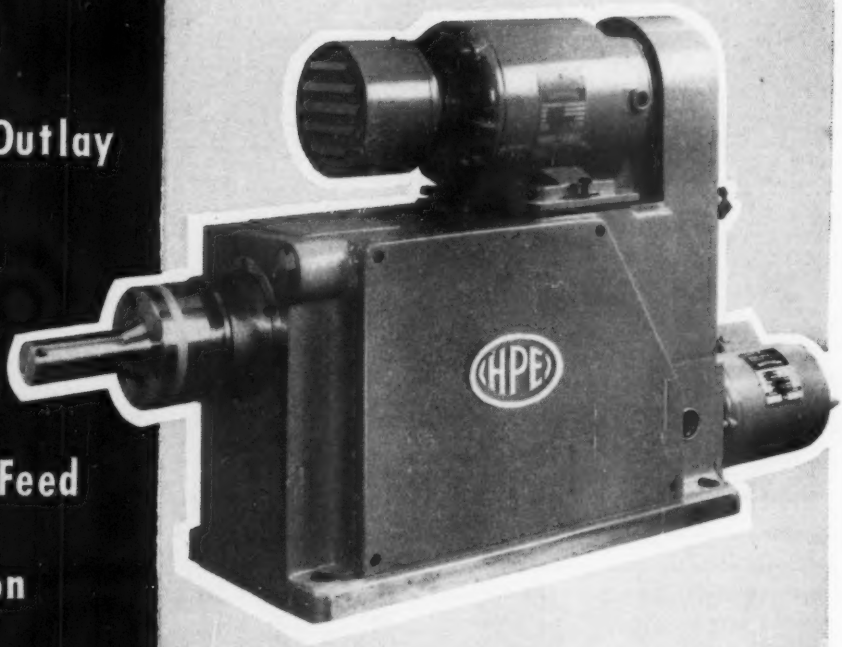

The FB4F Fine Boring Unit Head illustrated above incorporates an independent feed motion, transmitted to its spindle quill through a simple plate cam, which can be designed to give a fast approach and varying rates of feed. The robust spindle and quill, together with super precision spindle bearings, ensure a high degree of finish and roundness.

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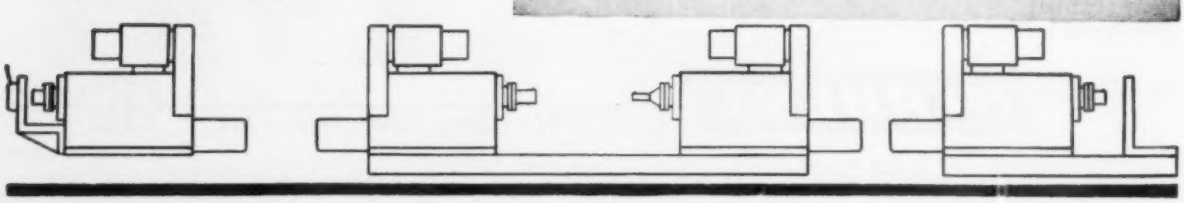
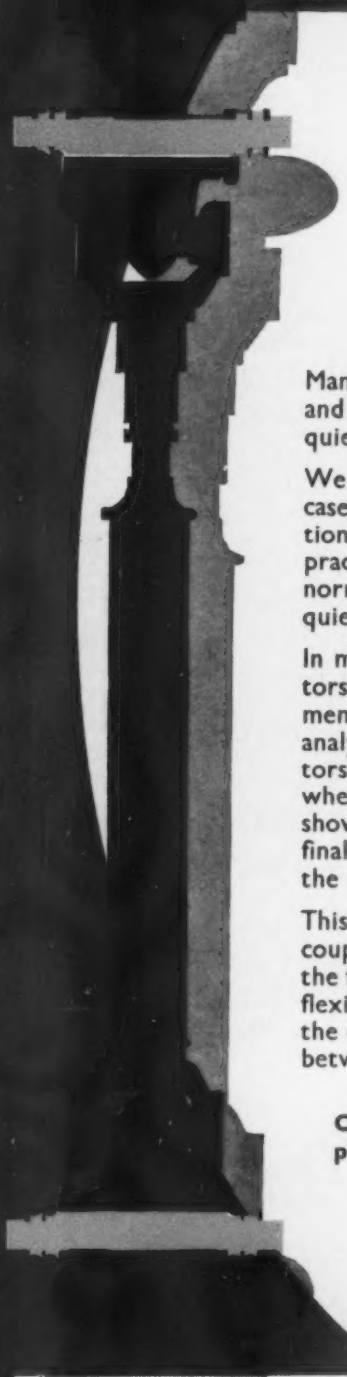


TRANSMISSION NOISE



How Metalastik tackle and solve the problems

Many transmission systems which, from their design and workmanship, could be expected to be reasonably quiet, do in fact turn out to be unexpectedly noisy.

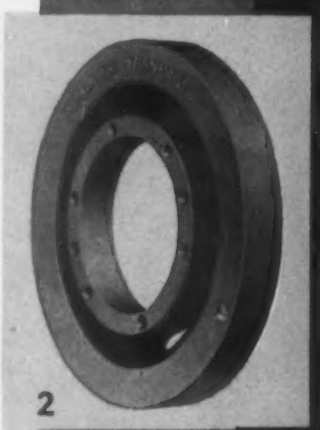
We have analysed and diagnosed a number of such cases, and find that as a rule resonant torsional vibration is the culprit, a conclusion which agrees with the practical observation by some engineers that a normally noisy transmission becomes markedly quieter when driven through a fluid flywheel.

In most cases, one or another form of the Metalastik torsional vibration damper makes a striking improvement. Two forms, shown at 1 and 2, are used when analysis has shown the trouble to be due to resonant torsional vibration or cyclic fluctuation of the flywheel. They can be fitted in either of the positions shown, either behind the gearbox or in front of the final drive. When the amplitudes are unusually large the Metalastik unit No. 3 is used.

This is not an inertia-type damper but a flexible coupling, in which low torques—at which most of the flutter occurs—are transmitted with considerable flexibility by a bush in torsion, the buffers taking up the drive only at high torque. This coupling is fitted between engine and gearbox.

Our engineers are always available to investigate problems and to bring to bear their unsurpassed experience.

1



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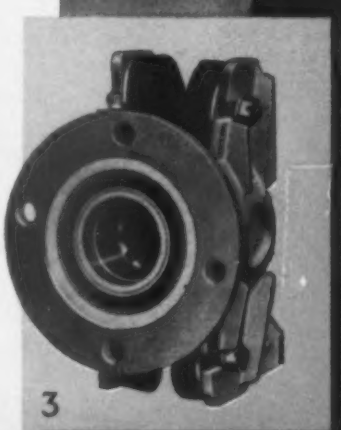
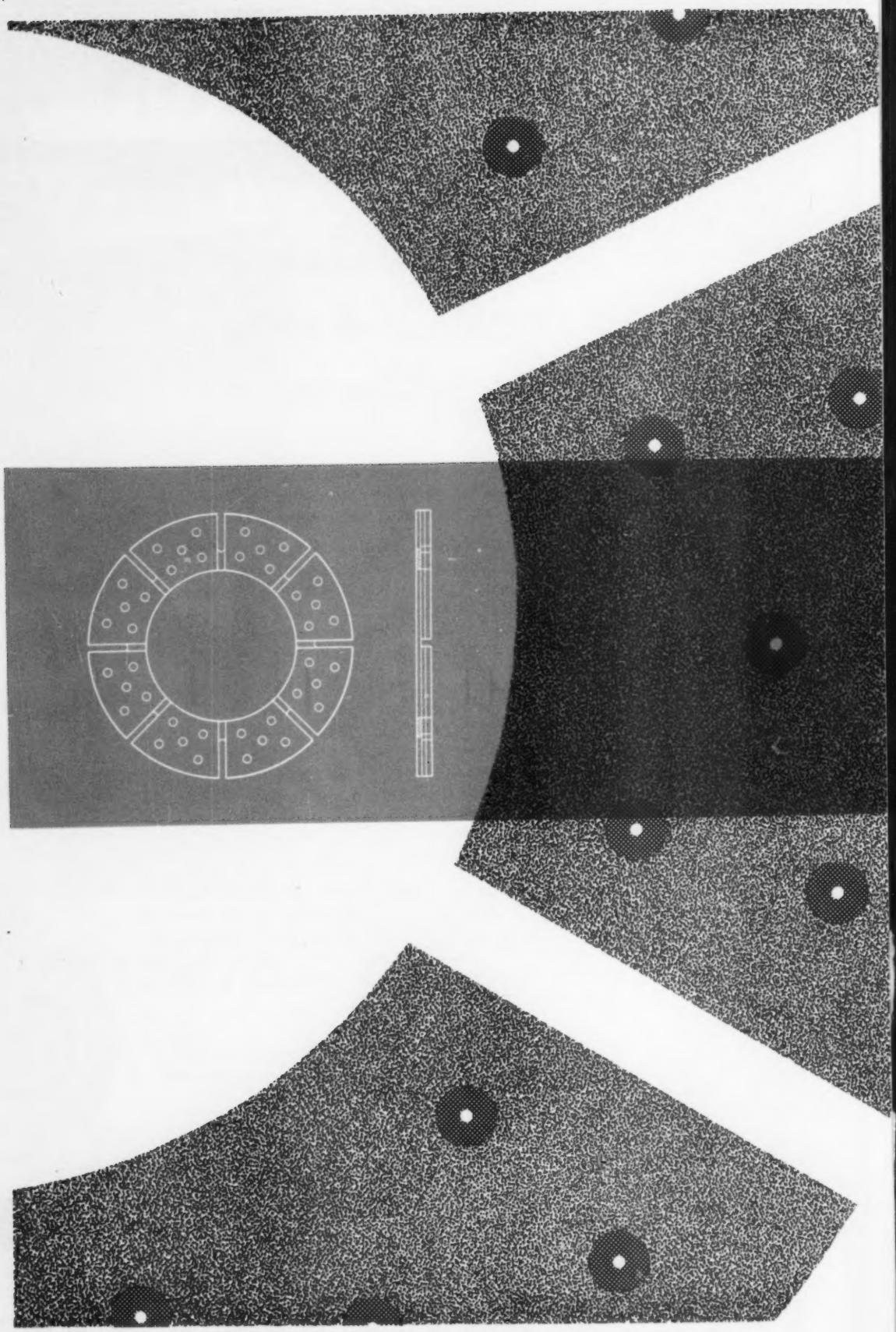


3

METALASTIK



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SM.2 For oil immersed applications requiring smooth, gradual engagement such as automotive automatic transmissions.

SM.3 Specially suited to dry, heavy duty applications such as engine master clutches on trucks and on tractor steering clutches.

SM.4 Is intended as a mating surface for use against other Ferodo sintered metals to protect costly parts from heat damage and wear.

SM.5 For oil immersed applications involving long slip periods such as seals and tension controlled clutches.

SM.6 For oil immersed applications where smooth engagement must be coupled with relatively high rating.

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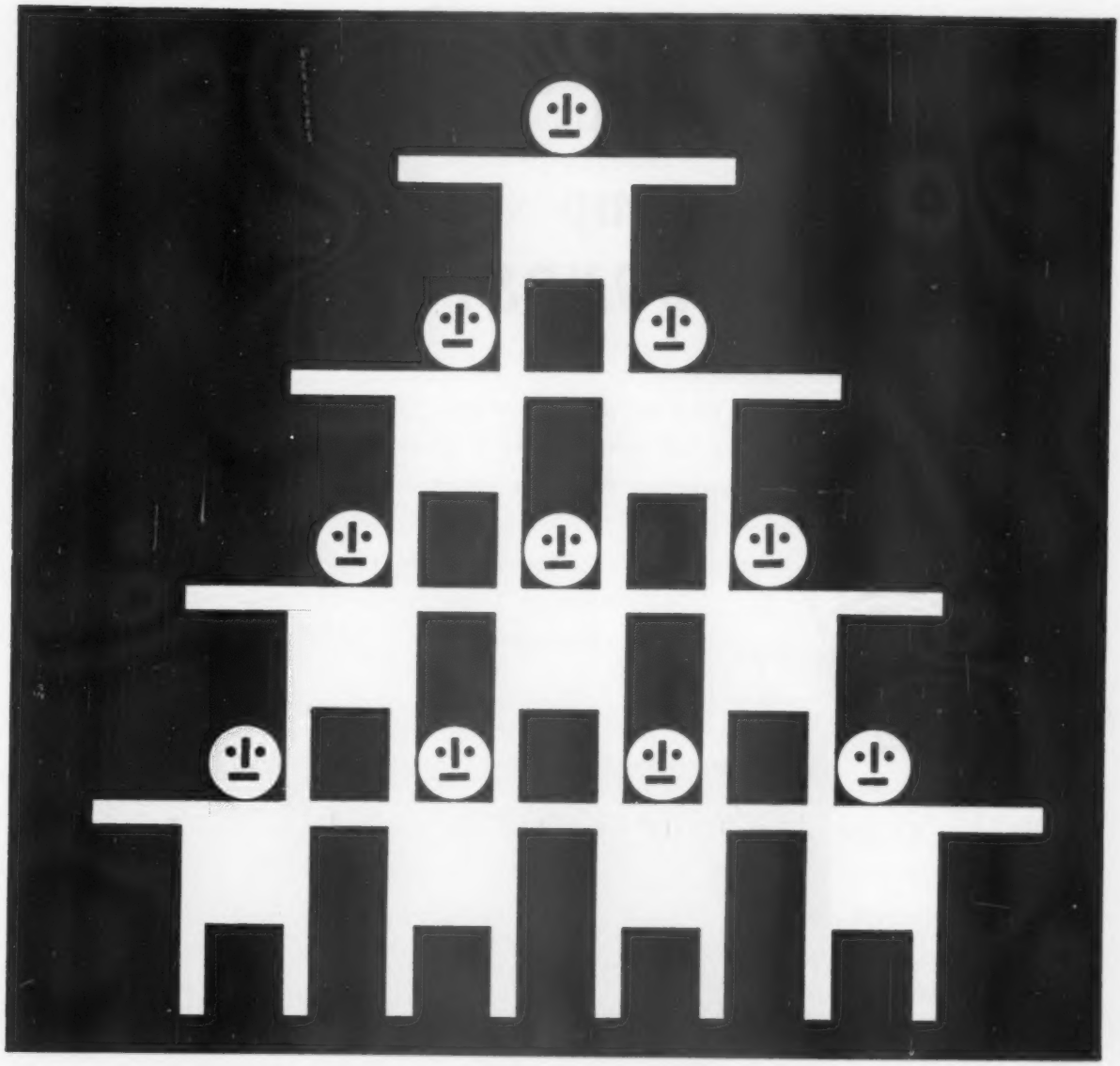

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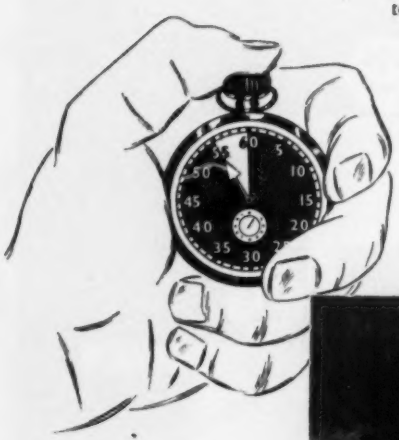

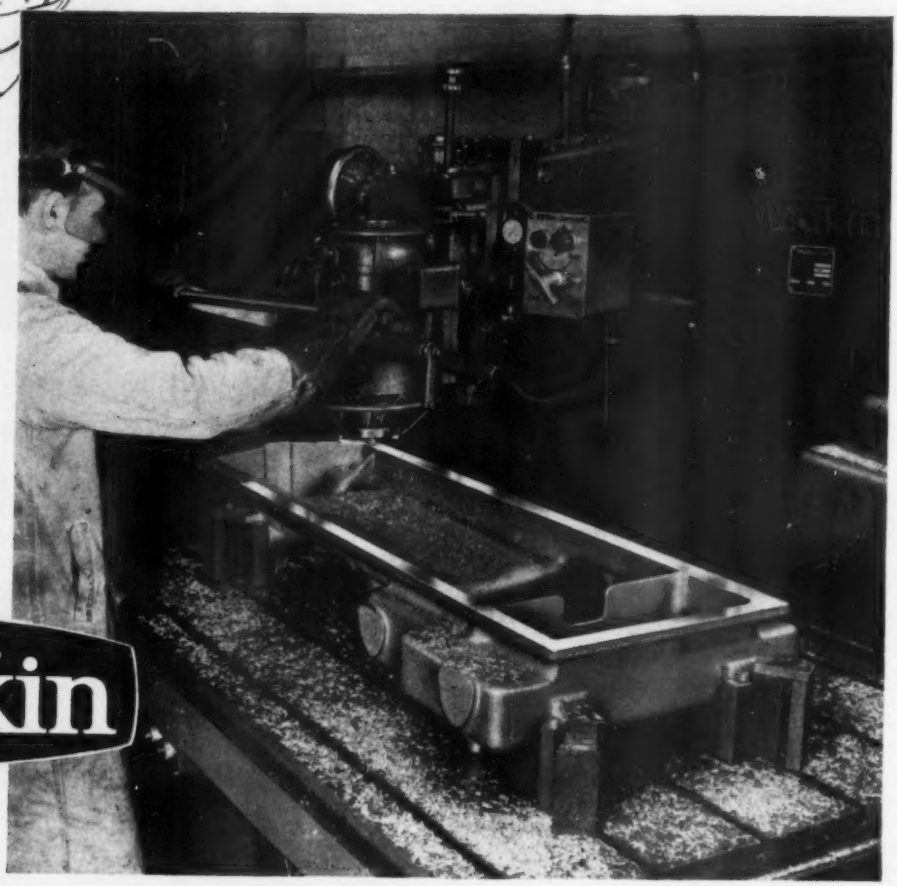

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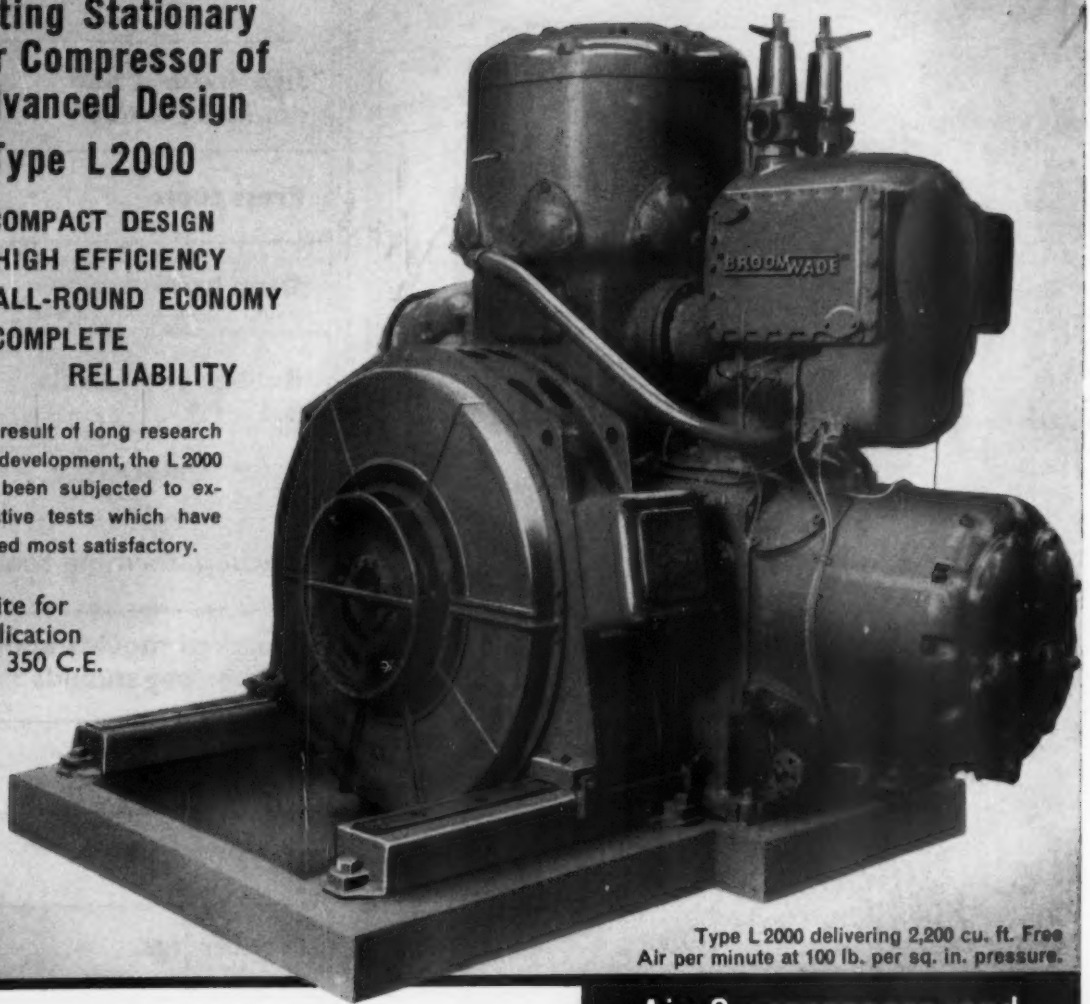

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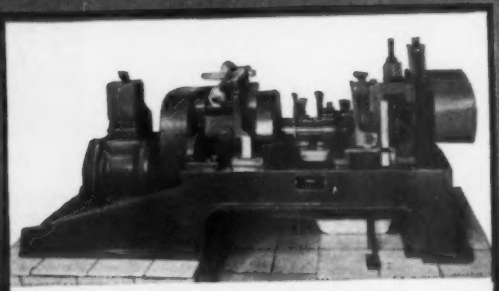

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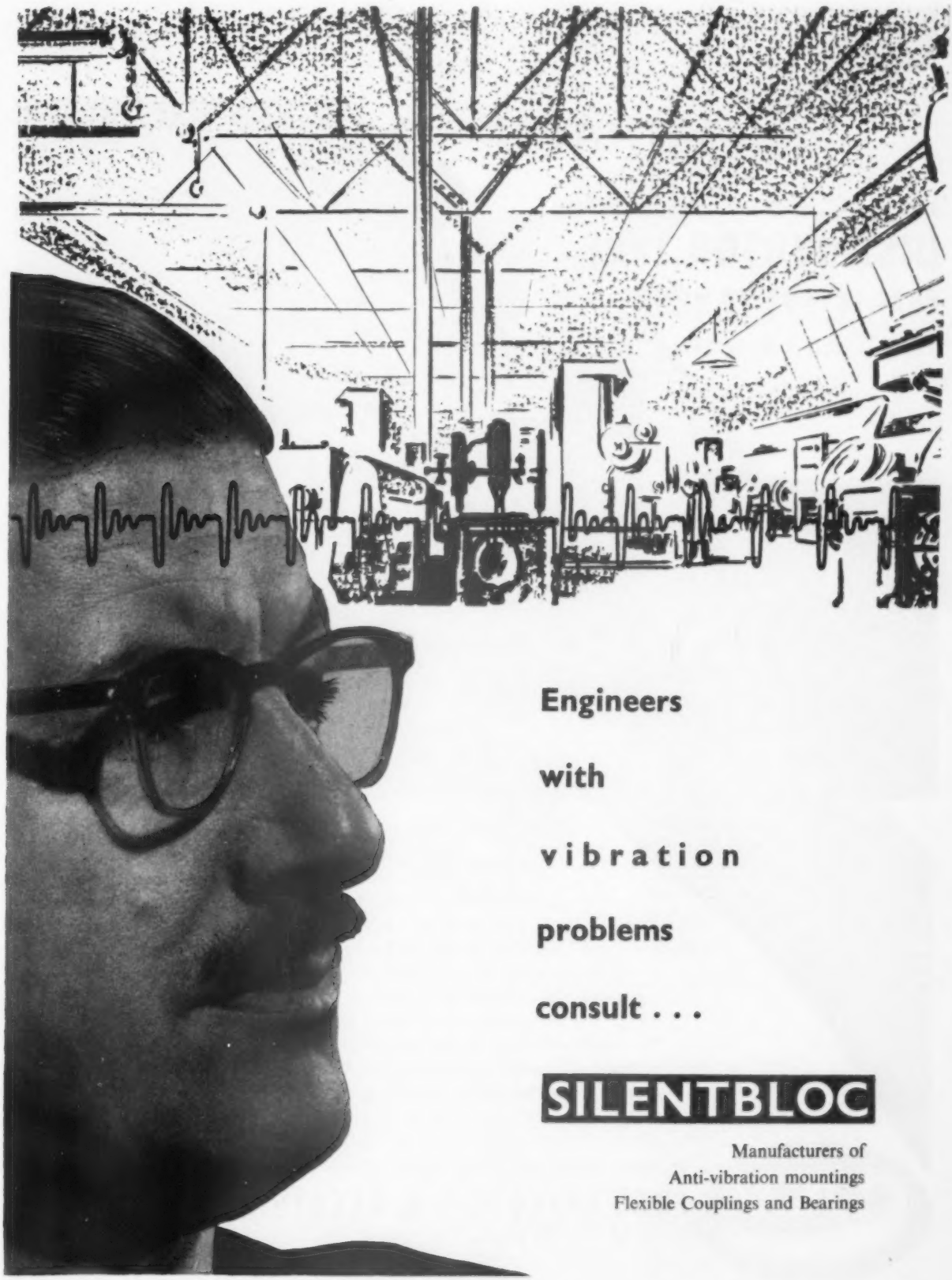

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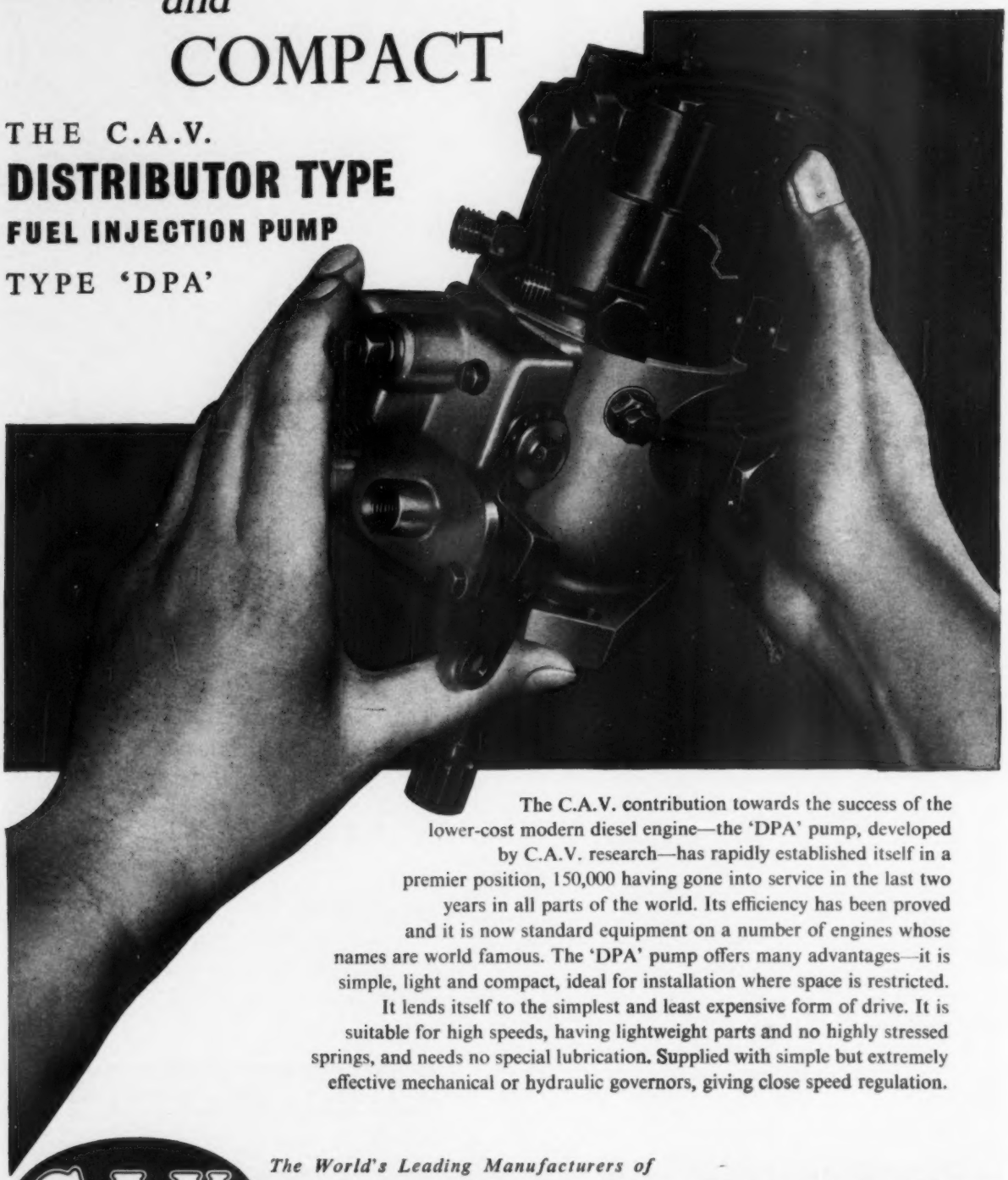

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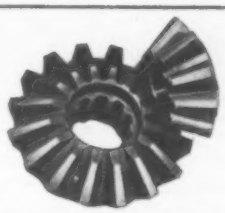

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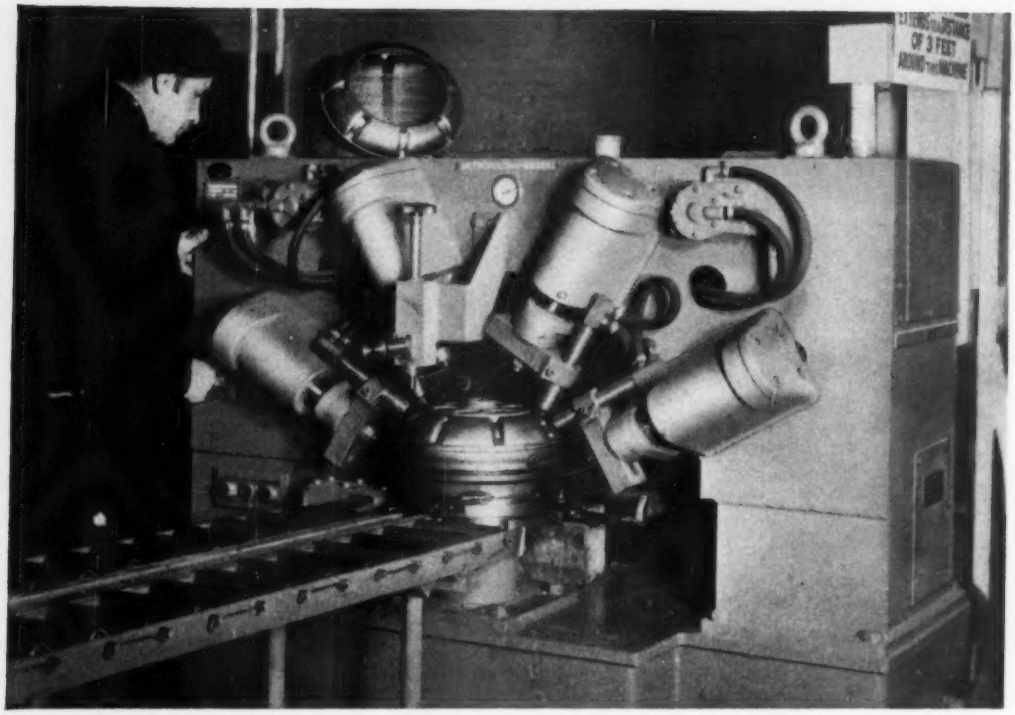

Borg-Warner automatic transmission used on British and Continental cars is now produced entirely in this country. The fabrication of the hydraulic torque converter is an achievement which depended largely on solving a number of welding problems. Distortion had to be avoided because of the close dimensional tolerances required in many components and only a small departure from true balance is permissible with the high rotary speeds employed in the converters. In addition, the economics of present-day production necessitated fast, automatic welding techniques. All of these exacting and important welding requirements have been met by the use of several different types of Metrovick automatic submerged arc and resistance welding equipments, including a number of machines specially designed for the job.

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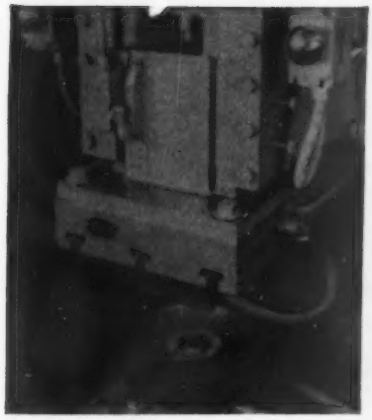


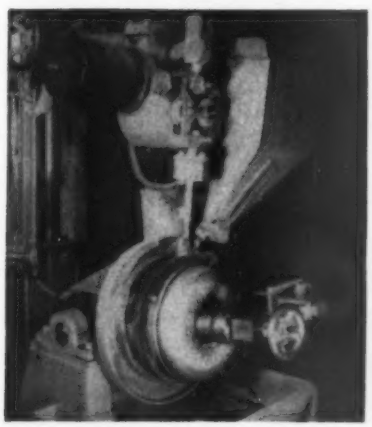
1. After the hub of the impeller has been pressed into its shell, the hub plate is welded inside the shell using a Metrovick 600 kVA projection welder.

2. For welding the hub to the impeller shell a Metrovick submerged arc unit is used. An essential feature of this machine is the electronic control of the arc.

3. After vanes have been inserted, a filler adapter drain plug is welded into the impeller shell. A counterbalance weight is welded on the diametrically opposite side. This is carried out on a Metrovick 150 kVA air-operated projection welder, automatically setting the weld time for each operation.

Fabricating the BORG-WARNER HYDRAULIC TORQUE CONVERTER

4. The turbine assembly must be balanced to within 0.1 oz.-in. Balance is corrected by spot welding strip metal on to the vanes using a Metrovick 50 kVA portable machine.



5. The completed clutch and flywheel assembly and the converter assembly are fitted together and then welded with a Metrovick submerged arc machine. This was specially designed for circumferential welds on Borg-Warner converter casings.

6. After testing the assembly for leaks a Metrovick Archway Type multi-spot unit is used to attach the blower. Sixteen spot welds are made with four air-operated heads. Control is by thyratron timer and ignitron contactor.

7. In the final balancing of the complete assembly this Metrovick 75 kVA portable spot welder is used for welding weights to the outer casing. The air-operated welding gun is mounted on a pivoting arm, balanced for ease of manipulation.

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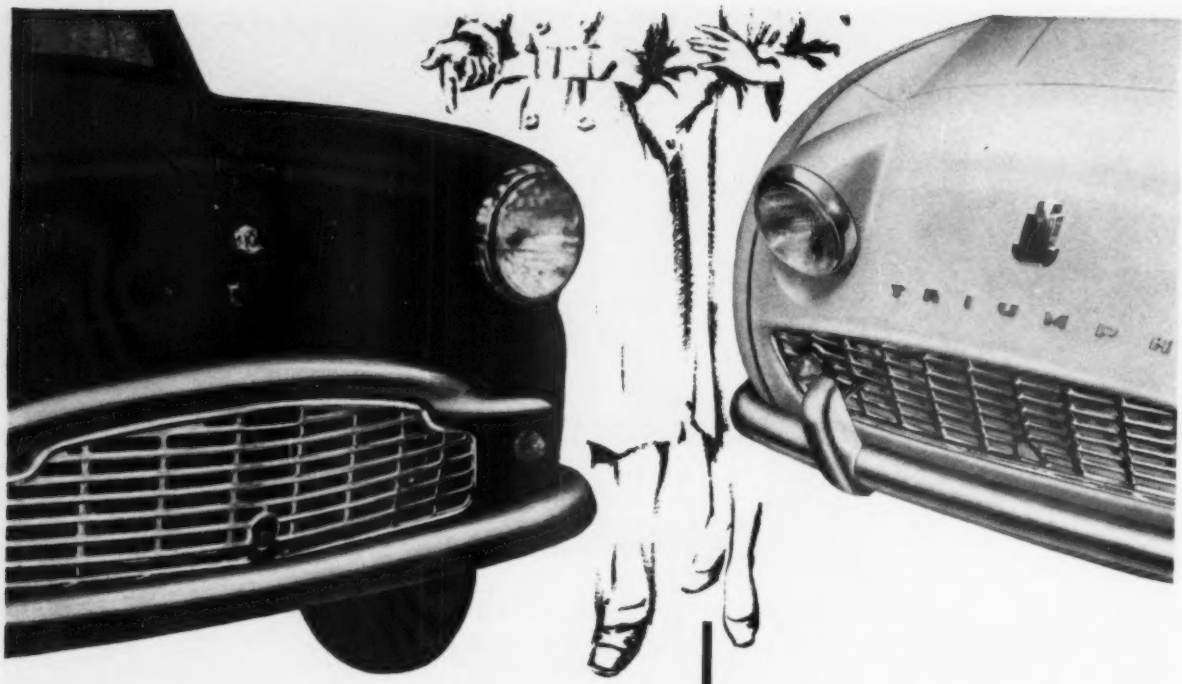

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All current models of the Triumph TR.3, Standard Pennant, Standard Ensign and Standard Ten are being fitted with Birmabright aluminium alloy radiator grilles, as a result of the outstanding success of the trials started over five years ago when Birmabright grilles were put into service on the Triumph TR.2. Chemically brightened and anodised by Charles & Watkins Ltd., these grilles are as attractive to look at as they are durable and trouble-free in use.

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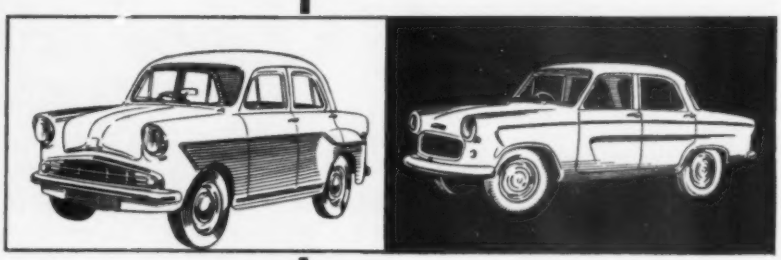

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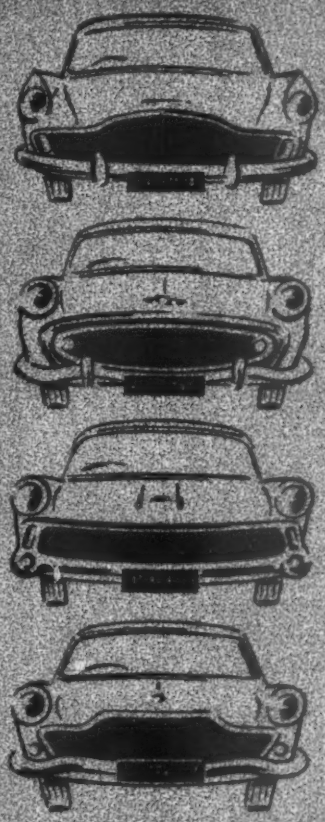

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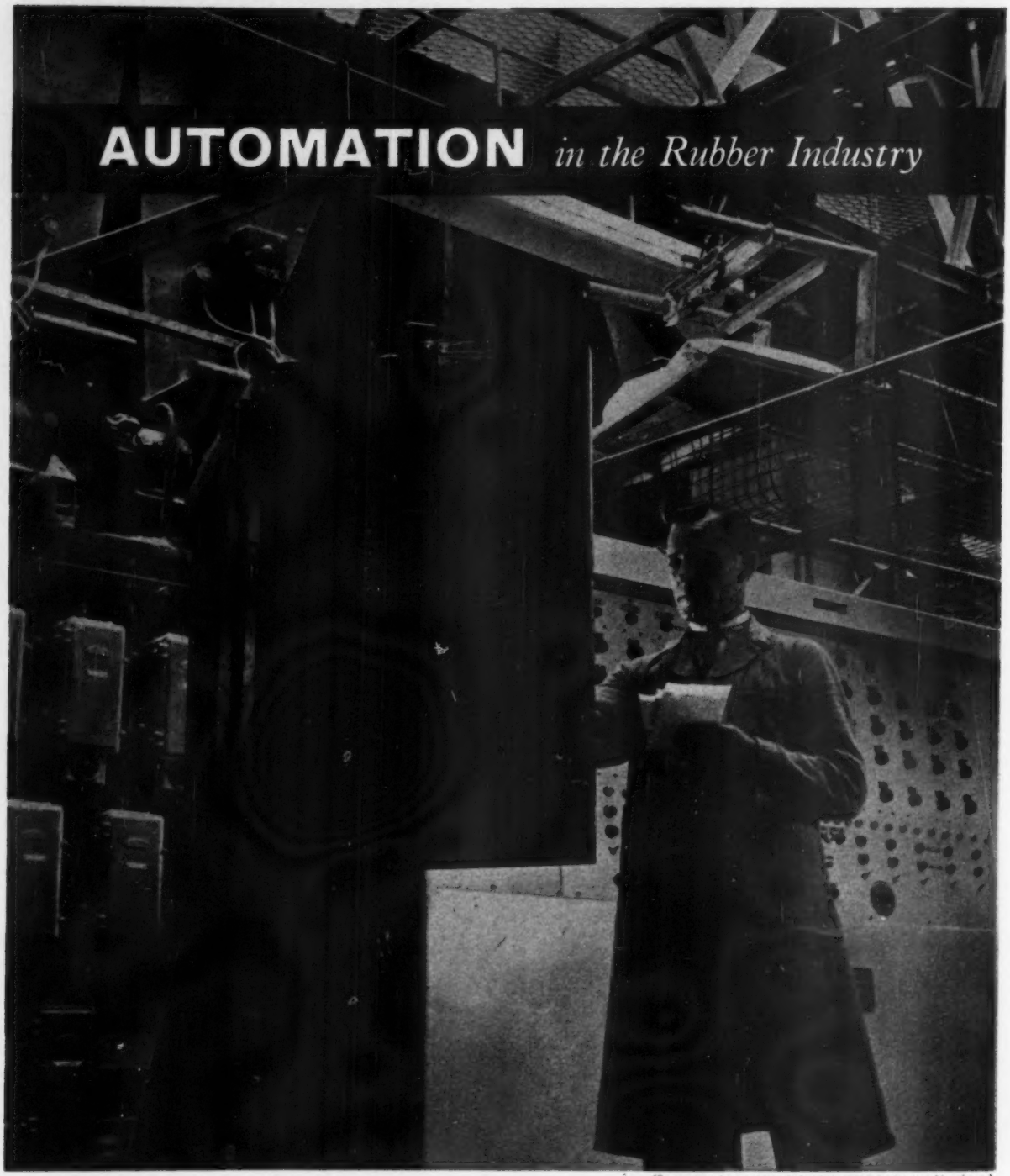

(By courtesy Engineering Ltd., photograph by Walter Nurnberg.)

Setting up a formulation in an automatic plant for compounding rubber

Rigid specifications and the concise requirements demanded by modern industry, call in turn for great accuracy in the compounding of rubber mixes. Here the operator at the control panel of the first automatic rubber compounding plant in operation in the British Isles, is seen determining the necessary ingredients and quantities, so as to ensure this accuracy. Thereafter the various silos situated above automatically release the required amounts into hoppers which then move into the rubber mill.

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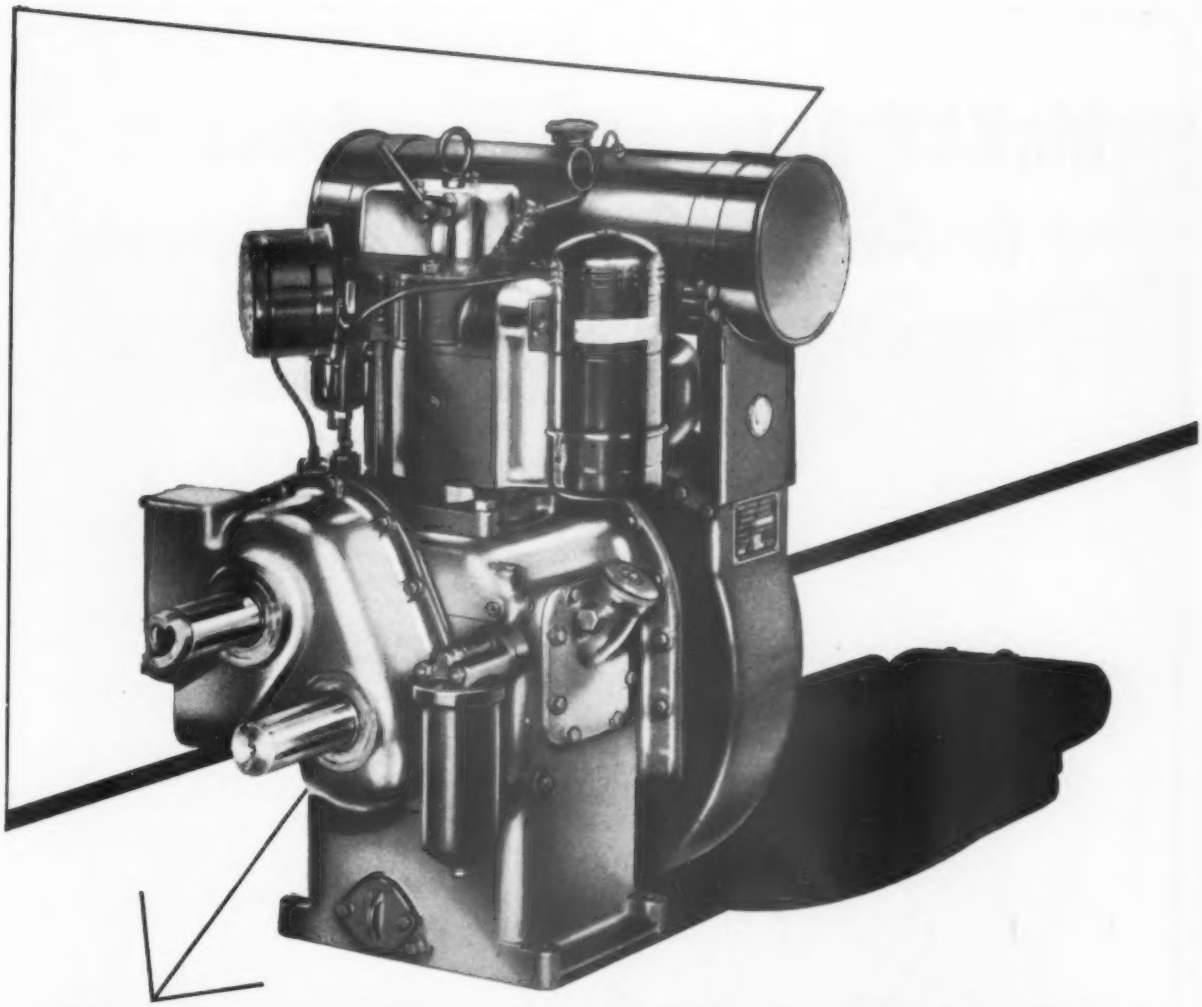

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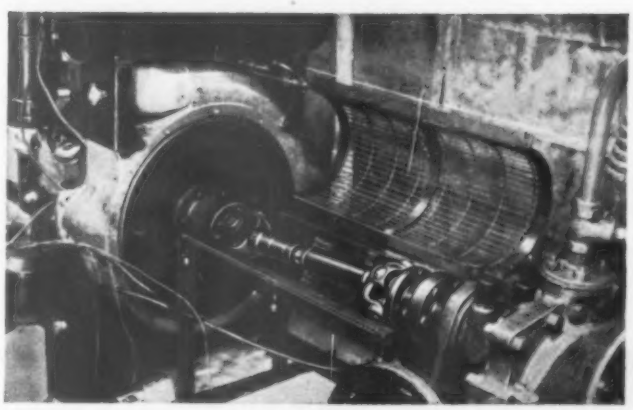

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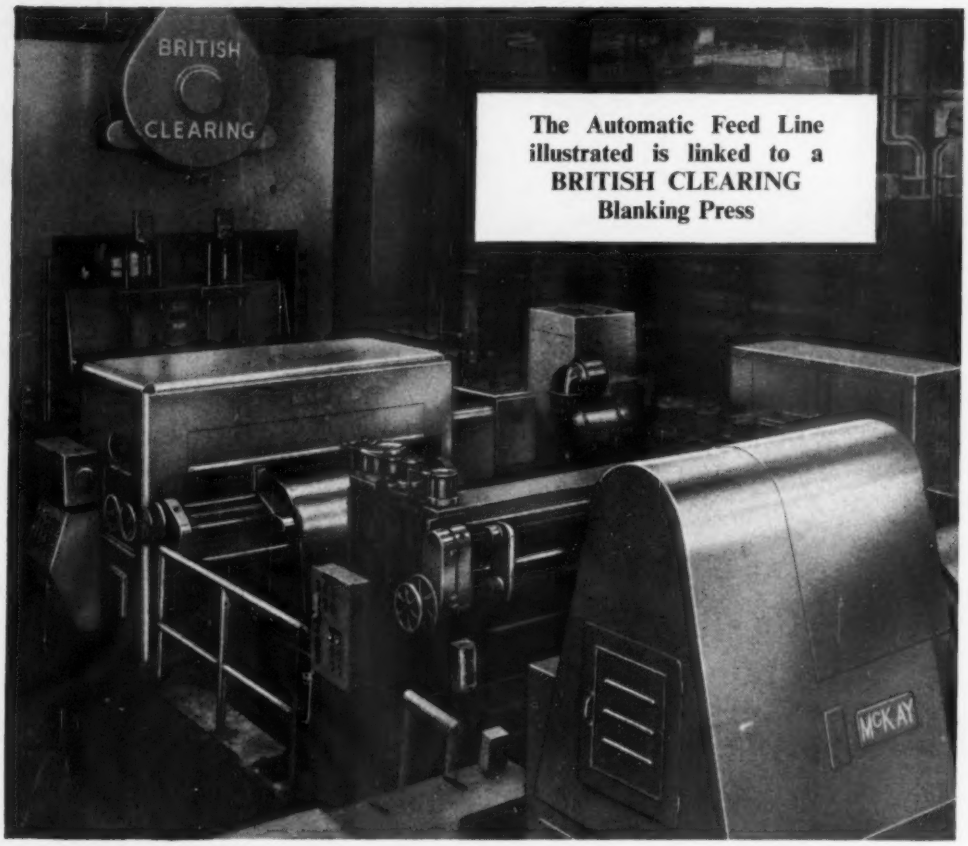

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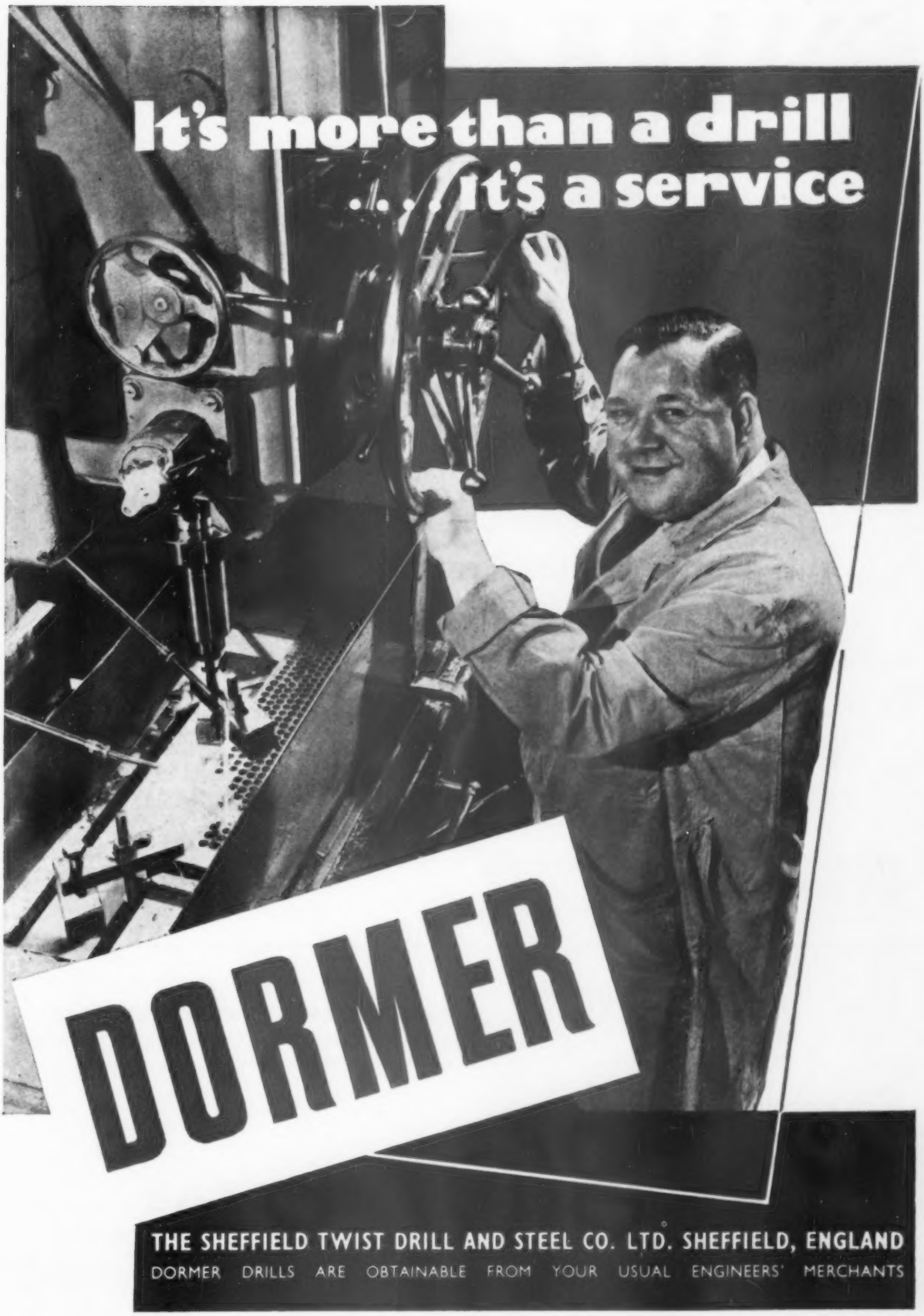
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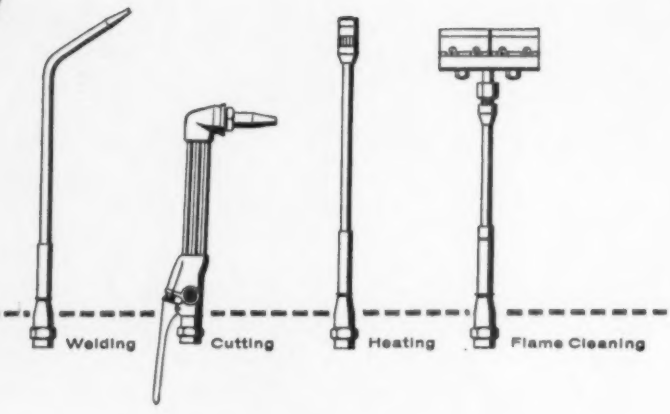

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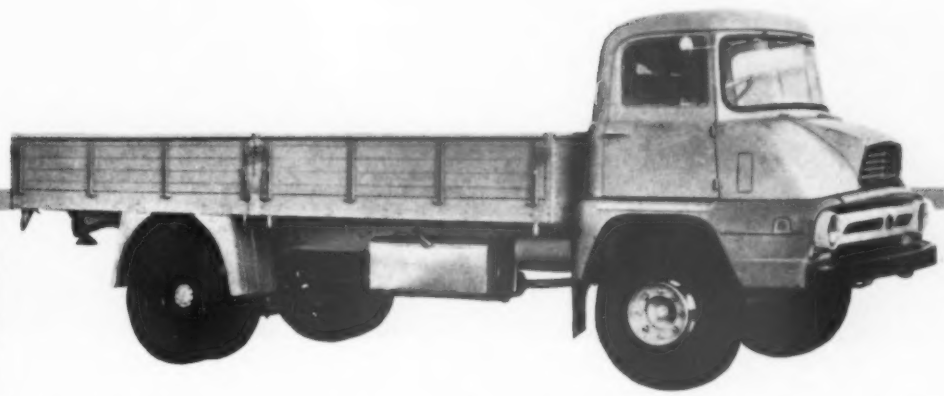

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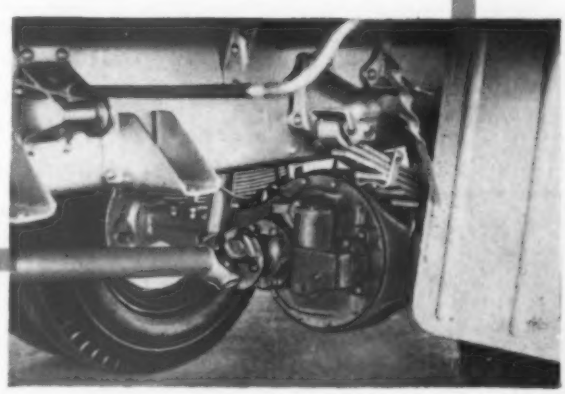

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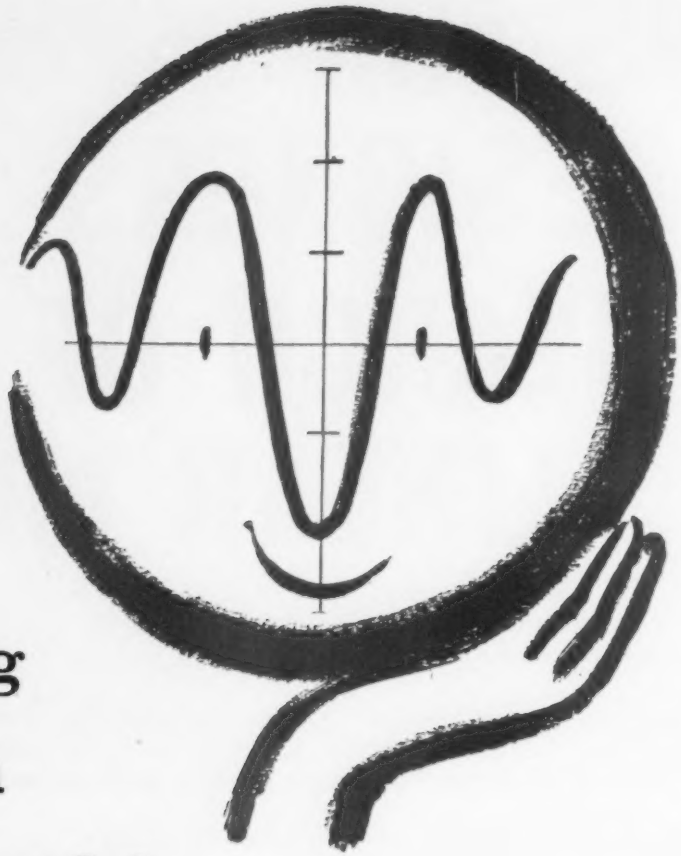

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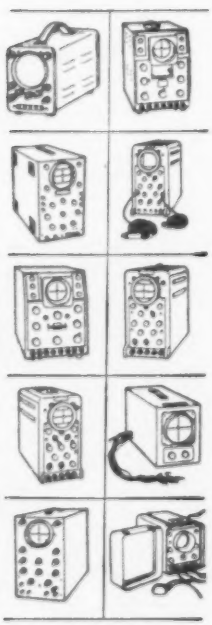

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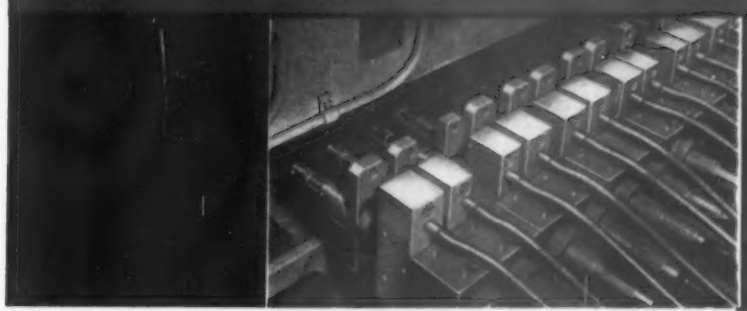
the SOLEX automatic gauging station

for the accurate sizing of valve guide bores



Close up view of multi-gauging heads

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Photos: courtesy Vauxhall Motors Ltd.

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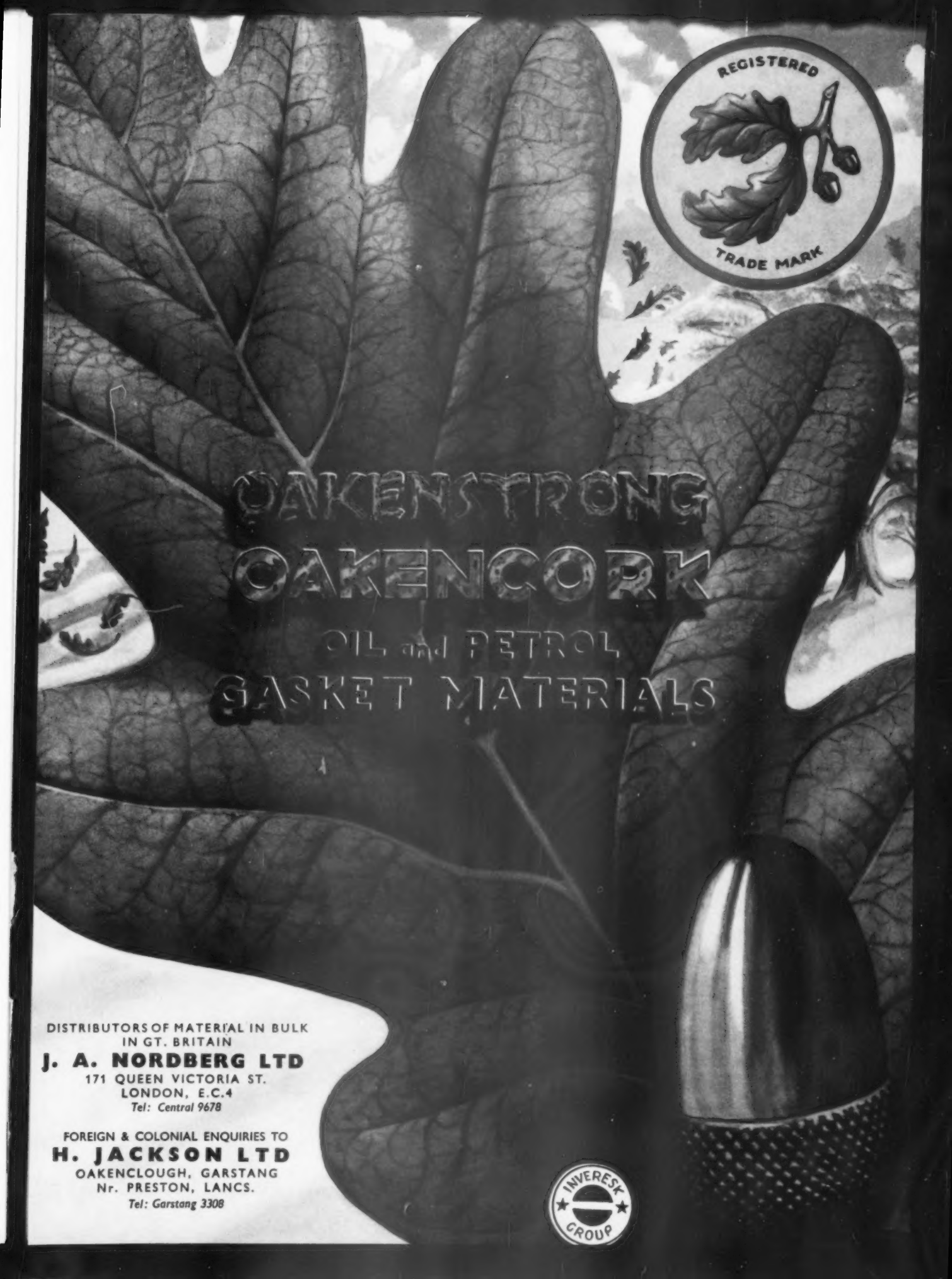

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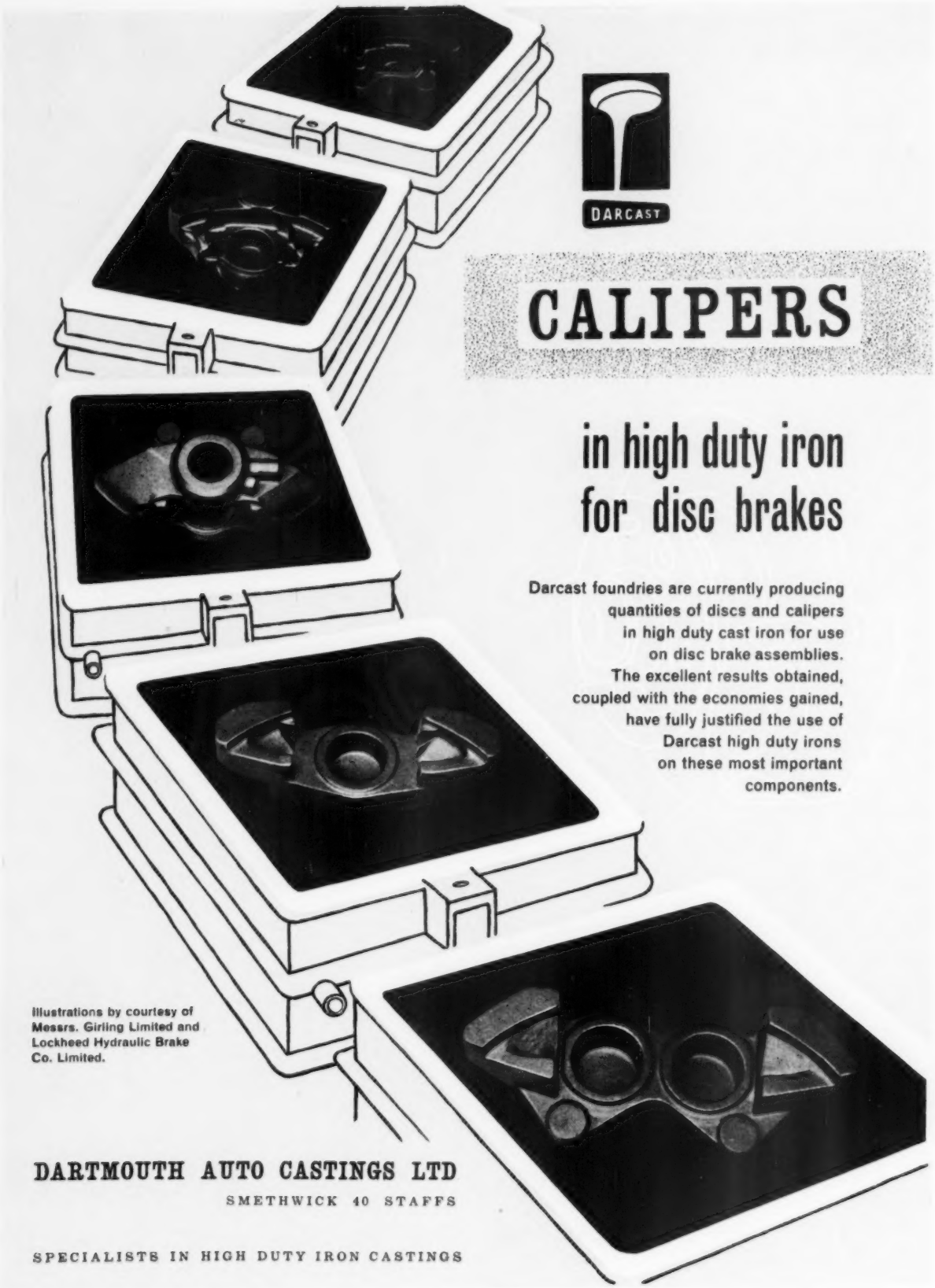

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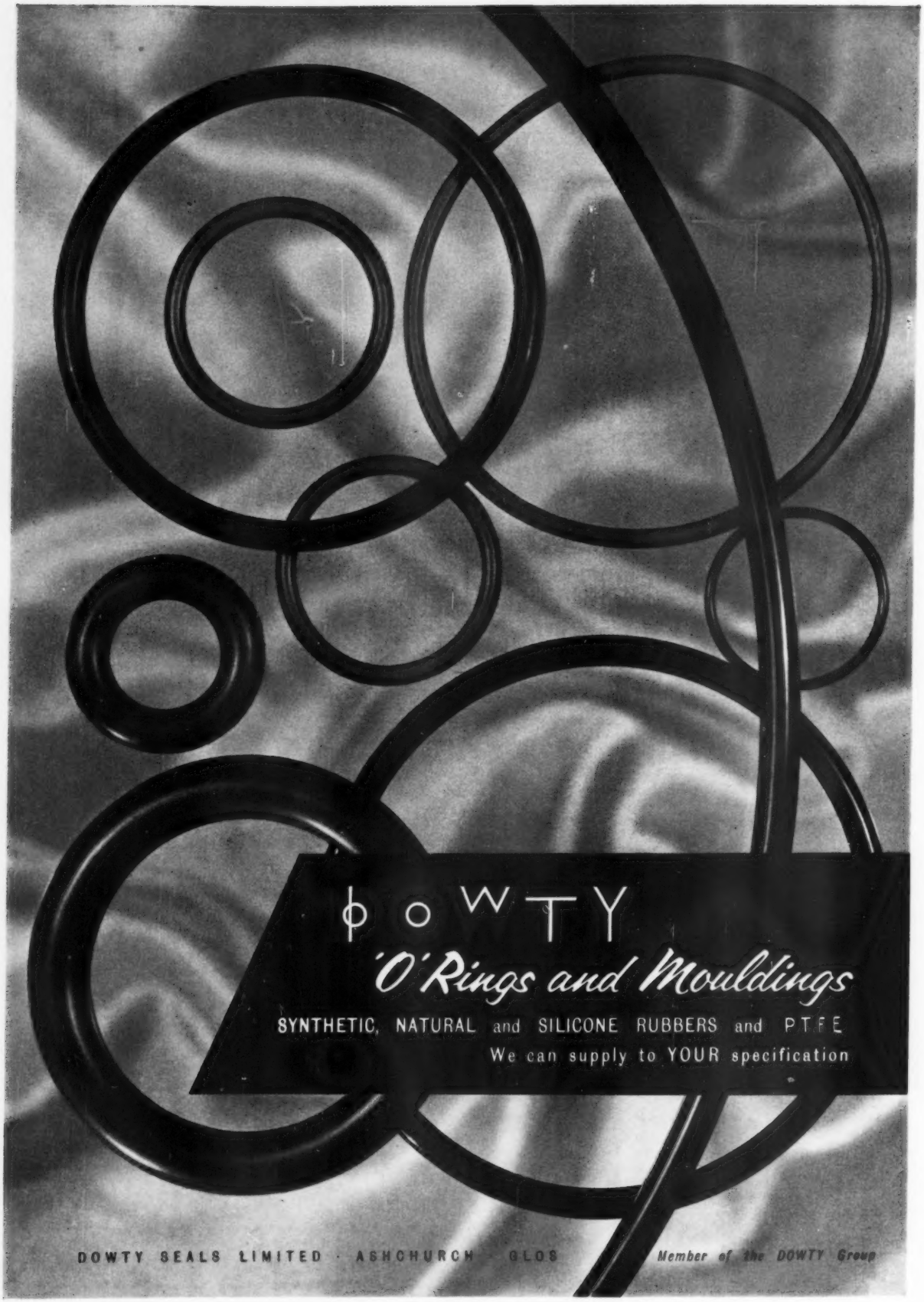
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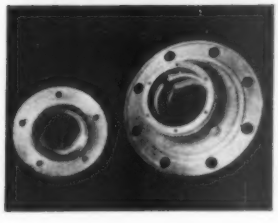

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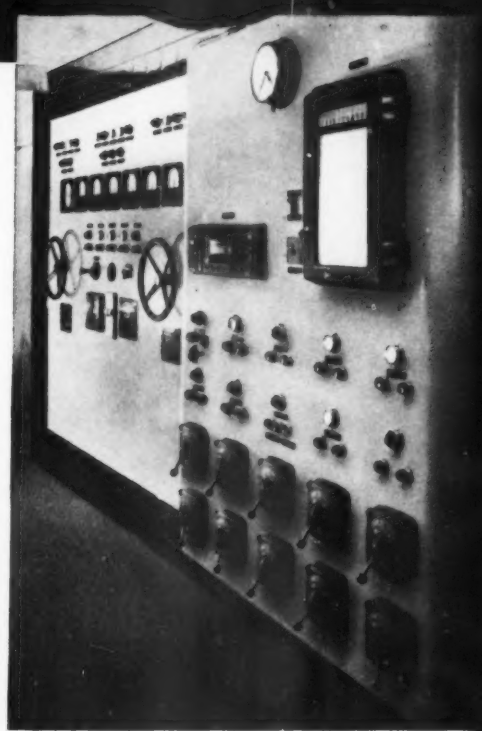

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CONTENTS

A DESCRIPTION OF THE BURMAN FP2 POWERED STEERING GEAR IS PUBLISHED IN THIS ISSUE. THE HYDRAULIC ASSISTANCE IS NOT EFFECTED BY EXTERNAL JACKS

41 Editorial *Vehicle Design for the New Motorways*

42 Rover Diesel Engine *Two-litre indirect injection unit for application in cross-country vehicles*

49 Burman Powered Steering *Recirculating-ball system with a built-in hydraulic assistance unit*

53 Disc Brakes J. O. Starling *Part II: Some of the developments since the Second World War*

60 British Coach Built Products *Interesting features of some of the latest custom built cars*

66 Flow Meter for Liquid Fuels D. N. MacDougall and K. Weiss *Description and operation of equipment embodying a device for automatic refilling of the measuring vessel*

69 Brake Test Equipment *A survey of interesting new apparatus now being used by Girling Ltd.*

72 Coolants for Chucking Automatics *The development of soluble oils suitable for high-speed operation with sintered carbide tools*

74 The Cold Extrusion Process *Equipment now being installed by Forgings and Presswork Ltd. for the supply of cold extruded components to industry*

78 Rotary Melting Furnaces *Some mechanical advantages of the tilting type of these economical production units*

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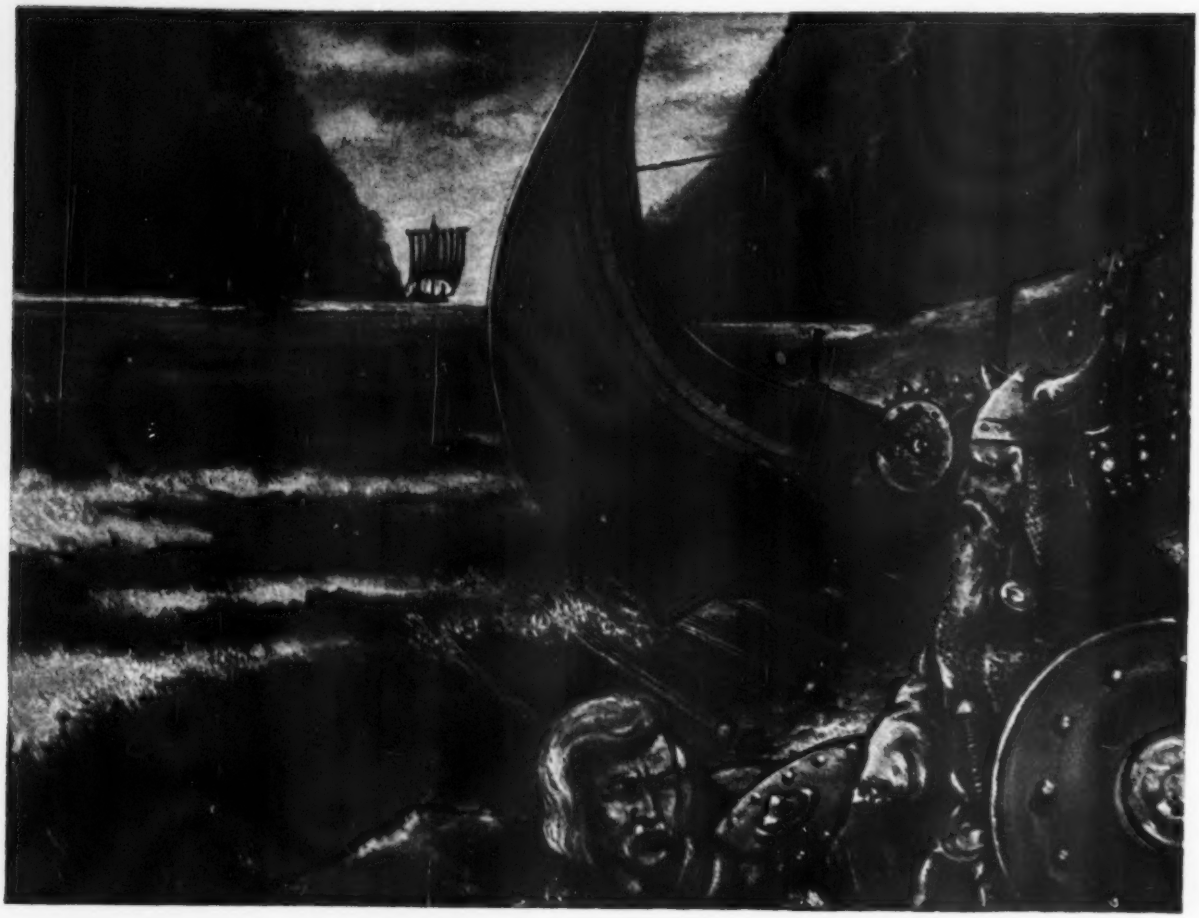

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Vehicle Design for the New Motorways

THE eight miles of motorway so far completed certainly is not enough to justify the introduction of design changes for operation on this kind of road. In fact, for some years all vehicles, except the few whose routes happen to be almost exclusively on the new motorways, will of course continue to operate principally on what are at present regarded as more normal classes of roads. However, in view of the fact that designers have to survey continually the fields in which changes are occurring, it is pertinent to review the problems of the design of vehicles for protracted operation at relatively high speeds.

First, however, it is necessary to establish what the speeds of operation are likely to be. Since for at least the last twelve years British manufacturers have been exporting their vehicles to countries that already have extensive motorway systems, a great deal of information on this and on the design problems is already available. In the United States, for example, the average speed of traffic on the trunk roads is 55 m.p.h. In general, the heavy commercial vehicles operate at about 50 to 55 m.p.h., and among the fastest vehicles are the long distance coaches which frequently travel at speeds even higher than those of most private cars.

In Europe the average speed on motorways is 53 to 55 m.p.h., and checks made recently on the Preston by-pass have indicated that the average speed there is approximately the same. It must be borne in mind, however, that the averages could be misleading: for example, if the traffic happened to comprise 70 per cent heavy vehicles operating at 35 m.p.h. and 30 per cent private cars travelling at 70 m.p.h., the average speed would be 45·5 m.p.h. and would not be representative of either class of vehicle.

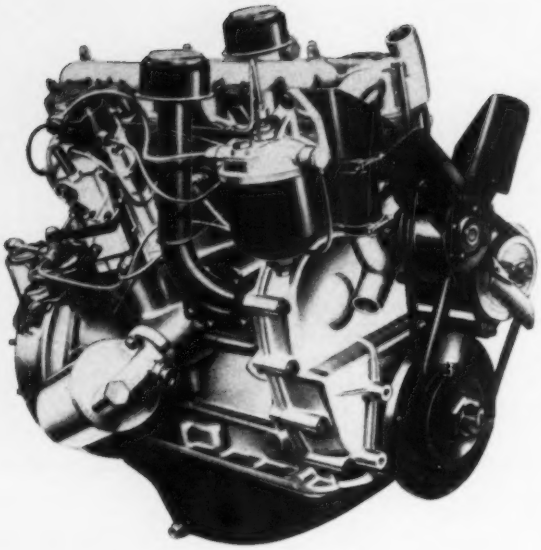
Although most cars will obviously have to continue to be designed to meet the demands of fast as well as average drivers, it is unlikely that commercial vehicle operators would want their vehicles to exceed speeds of about 60 m.p.h., even if legal restrictions were removed. Stability and ease of holding vehicles on a straight course must be carefully considered in the overall design of vehicles for high-speed operation. Aerodynamic stability at high speeds, not only of private cars but also of vehicles such as coaches and pantechnicons, will tend to become a significant factor in design. This subject was dealt with at some length in an article in the June and July 1958 issues of *Automobile Engineer*.

When the motorway system has been extended, there will be a tendency for engines of higher output to be demanded. Fuel specifications will have to be considered in relation to valve life, since there is a greater tendency for deposits to build-up on the valves during protracted operation at constant speed and load. Under conditions of high-speed operation, perhaps the most important factor to be considered is engine temperature. In current designs of both British and foreign manufacturers, the oil temperature tends to rise steadily under these conditions. Larger capacity oil sumps would help to remedy the situation, and an adequate flow of air round the sump is necessary. So far as viscosity of the lubricant is concerned, the recently introduced multigrade oils are probably adequate at higher temperatures, but their performance in other respects, notably at high rates of shear in bearings, where local depolymerization might occur, is open to question.

Overdrives may be more widely used and this will help to stabilize oil temperatures as well as reduce fuel consumption and noise. Alternatively, top gear flexibility might have to be sacrificed to some extent to obtain a higher cruising speed. Wheel and tyre balance certainly ought to be better than at present.

If the motorways are adequate in all respects for the traffic they will be called upon to carry, the need for changes in braking capacity might not be great. It would appear that moderately hard braking for relatively long periods will be called for much more often than the extremely hard braking for short periods that is commonly required on other roads. Therefore, although slight improvements might be called for in braking performance of private cars, heat dissipation will be the main problem. For heavy commercial vehicles, however, considerable improvements in braking power are required, but heat dissipation arrangements also must not be overlooked. There is a case for the adoption of exhaust brakes as standard equipment on heavy commercial vehicles operating under these conditions, and serious consideration should be given to the desirability of amending the legal regulations so that separate power assisted hand brake systems could be employed. An anti-skid device, to prevent the locking of the wheels when brakes are applied hard, is certainly desirable though possibly expensive.

The tendency for drivers to fall asleep after long periods at the wheel under monotonous driving conditions must be avoided. In this connection, improvements are needed in respect of heating and ventilation. Drivers' seats in heavy commercial vehicle cabs should certainly be adjustable, as also perhaps might be the steering columns. To reduce noise levels, the underfloor layout for forward control vehicles should be considered more seriously than hitherto.



The Rover diesel engine was designed from the outset for operation with the C.A.V. distributor type fuel injection pump. From the illustration on the left, it can be seen that the pump installation is compact, accessible and, since the unit is driven by a spiral gear on the camshaft, the timing drive arrangement is common with that of the petrol engine

ENGINE DATA

Number of cylinders	4
Bore × stroke	3⅜ × 3½ in (85·7 × 88·9 mm)
Swept volume	125·17 in³ (2,053 cm³)
B.h.p.	51·2 at 3,500 r.p.m.
Torque	86 lb-ft at 2,000 r.p.m.
B.m.e.p.	104 lb in² at 2,000 r.p.m.
Compression ratio	22·5 : 1

Rover Diesel Engine

Two-Litre Indirect Injection Unit for Application in Cross-country Vehicles

No vehicle can compete in commercial, industrial and agricultural markets unless it is offered, at least optionally, with a diesel engine. In these applications, high mileages are common, and the fuel economy soon offsets the difference in first cost. In entering these markets with the Land-Rover, the Rover Co. Ltd. were aware that the demand for a diesel engine would grow, so development was put in hand. It was not, however, until 1957 that the 2-litre Rover diesel engine came into production.

In the first stages of development, attempts were made to adapt the existing petrol engine, with its sloping head and unique valve arrangement. It was soon found, however, that the design was not suitable as a basis for a diesel unit, and entirely fresh designs were started. At the same time it was felt desirable to have alternative petrol and diesel forms of the same basic engine, so this was borne in mind from the start, and in actual fact the diesel version was in production some months before the 2¼-litre petrol version.

By the time plans were laid for the new engines, the distributor type fuel injection pump being developed by C.A.V. Ltd. was well advanced. To avoid duplication of timing drives, and other complications associated with the accommodation of in-line fuel injection pumps, it was decided that the engine should be designed from the beginning for the distributor pump, which was to be driven by skew gear from the camshaft.

The introduction of the distributor injection pump was inevitably attended by certain difficulties, due largely to the radically different systems of metering and control. Most of these, however, have been overcome or accommodated in the course of development.

Although there are many interesting and unusual features in the general design of the engine, it is natural that the main history of development work has centred round the fuel injection and combustion systems. Indirect injection is used in conjunction with Ricardo Comet Mark V combustion chambers and Pintaux injector nozzles.

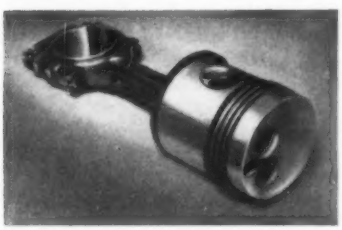
It is generally recognized that fuel injection equipment has been one of the major factors limiting the increase of engine speed. The engine itself has been designed to cope with inertia stresses and other effects of speeds up to 4,000 r.p.m. and more—the 2¼-litre petrol engine peaks at 4,500 r.p.m.—but at the present stage of development of the fuel injection and combustion systems without an automatic advance, the maximum speed is set at 3,500 r.p.m. at full load, or 3,650 r.p.m. at no load. Even at this speed, very high temperatures are developed and some incipient troubles with excessive cracking round the throat area of the hot-plug—the lower detachable component of the combustion chamber—were experienced. The possibility of trouble from this source occurring has been minimized by the adoption of Nimocast 80, the casting version of Nimonic 80. The combustion chambers are cast by the lost wax process, which results in an extremely clean finish, so much so that the throat and interior surface of the chamber are left as cast, and the only machining necessary is that on the outer diameter, flange and bottom face, which are ground. All these castings are given solution heat treatment, followed by precipitation.

The injectors are inserted in the cylinder head at an angle of 28½ deg from the vertical, and the auxiliary nozzle for starting and slow running is drilled at an angle of 20 deg from the axis of the injector, directing the auxiliary spray at the centre of the combustion chamber, slightly towards the upstream side. The lift of the pintle nozzle valve before the main nozzle orifice comes fully into operation is 0·25 mm. Thus, the transition takes place at a relatively early stage. The starting glow-plugs are inserted horizontally at a slight angle, but nearly directly in line with the throat. Since there is a slight step from the inner end of the throat passage to the conical side-wall of the chamber, it is thought that a slight reverse swirl is created which tends to carry the

mixture well into the glow-plug pocket, and it has therefore not been found necessary, for satisfactory starting from cold, for the glow-plug elements to project far into the chambers. Being protected by their pockets, the glow-plugs have proved to have an unusually long life.

On early experimental engines it was found that fuel temperatures in the region of 165-170 deg C were reached in the injector nozzle, and some trouble was experienced with lacquer formation in the nozzle valve. Furthermore, the slight clearance between the nozzle and the cylinder head soon became filled with hard carbon, making extraction of nozzles difficult. This trouble has been overcome completely, and temperatures reduced comfortably below the 135 deg C maximum recommended by the oil companies, by increasing the diameter of the bore in the cylinder head so that it is appreciably greater than the diameter of the nozzle, and by fitting a flanged thimble in the bore, the lower end of the thimble being shaped to blend the nozzle tip into the chamber. This thimble is made of En 52, and the flanged end provides a seat for the normal copper sealing washer on to which the nozzle holder is clamped. The recess in the thimble is machined to a depth which, when the nozzle holder is clamped down on the copper sealing washer, leaves a clearance of about 0·035 in between the bottom of the recess and the bottom face of the nozzle. In this clearance a small mild steel corrugated washer is inserted. The initial effective thickness of the washer is approximately 0·050 in, so that it is compressed about 0·015 in. This dimension is not critical, but the washer forms an effective barrier against heat. Not only is lacquering of the nozzle valve now practically eliminated, but the nozzles no longer become stuck in the thimbles and it is possible—indeed it is the normal practice—to remove the clamp bridge-pieces on all the nozzle holders, disconnect the high pressure pipes and lift out the four holders, with the spill pipe gallery, as an assembly. Injection takes place 16 deg before T.D.C., and the nozzle valves are set to open at a pressure of 135 atmospheres.

The fuel injection pump is spigoted and flange-mounted on a large pad machined on the side of the crankcase. It is inclined at an angle of 15 deg from the vertical. The mounting holes for the three attachment studs are slotted to allow 12 deg movement for injection timing adjustment. To provide for stationary working at fluctuating loads as well as for normal driving on the road, the pump is controlled by a centrifugal all-speed governor incorporated in the pump body. A hydraulically operated automatic advance mechanism was originally fitted on the pump, but it was found in practice to be unnecessary for speeds up to 3,500 r.p.m. and was subsequently omitted from the specification.

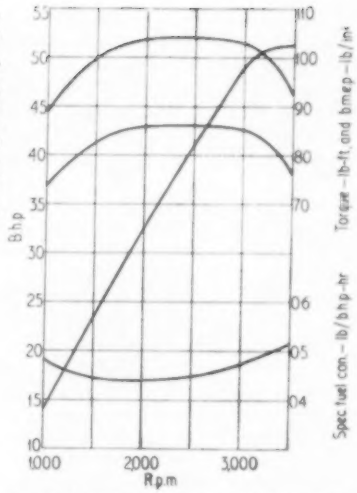


One of the earlier piston assemblies, with a heart-shape recess in the crown

Since the pump is centrally positioned on the engine, a symmetrical layout of the high pressure delivery pipes is easy to arrange. There are two delivery ports on each side, one has a straight union and the other a banjo, so that the pipes are parallel, and the pipe with the shorter run in each pair is led round in a compensating curve. Solid drawn pipes, with a 3 mm bore, are employed. They have integral nipples upset at both ends. The plunger in the injection pump is 6 mm diameter.

Fuel is supplied to the injection pump by an AC mechanical pump mounted on one of the tappet covers and driven by an eccentric on the camshaft. The feed pump is identical with that fitted to the petrol engine except for the provision of a stronger spring to deliver fuel at a pressure of 5-8 lb/in², which is necessary to avoid aeration in the metering section of the injection pump.

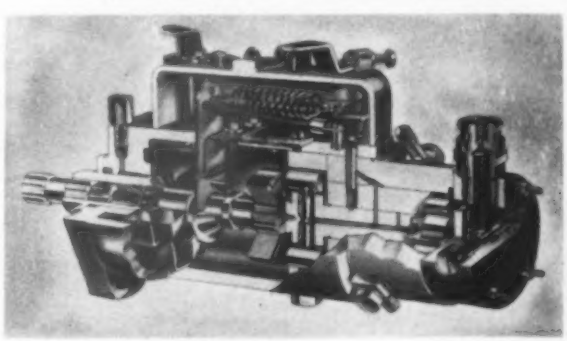
Power curves at the maximum fuel setting, with the exhaust just visible, at an operating speed of 1,500 r.p.m. The test was conducted on the engine as installed in the Land-Rover vehicle, and with the barometric pressure at 760 mm of mercury and the air inlet temperature 60 deg F

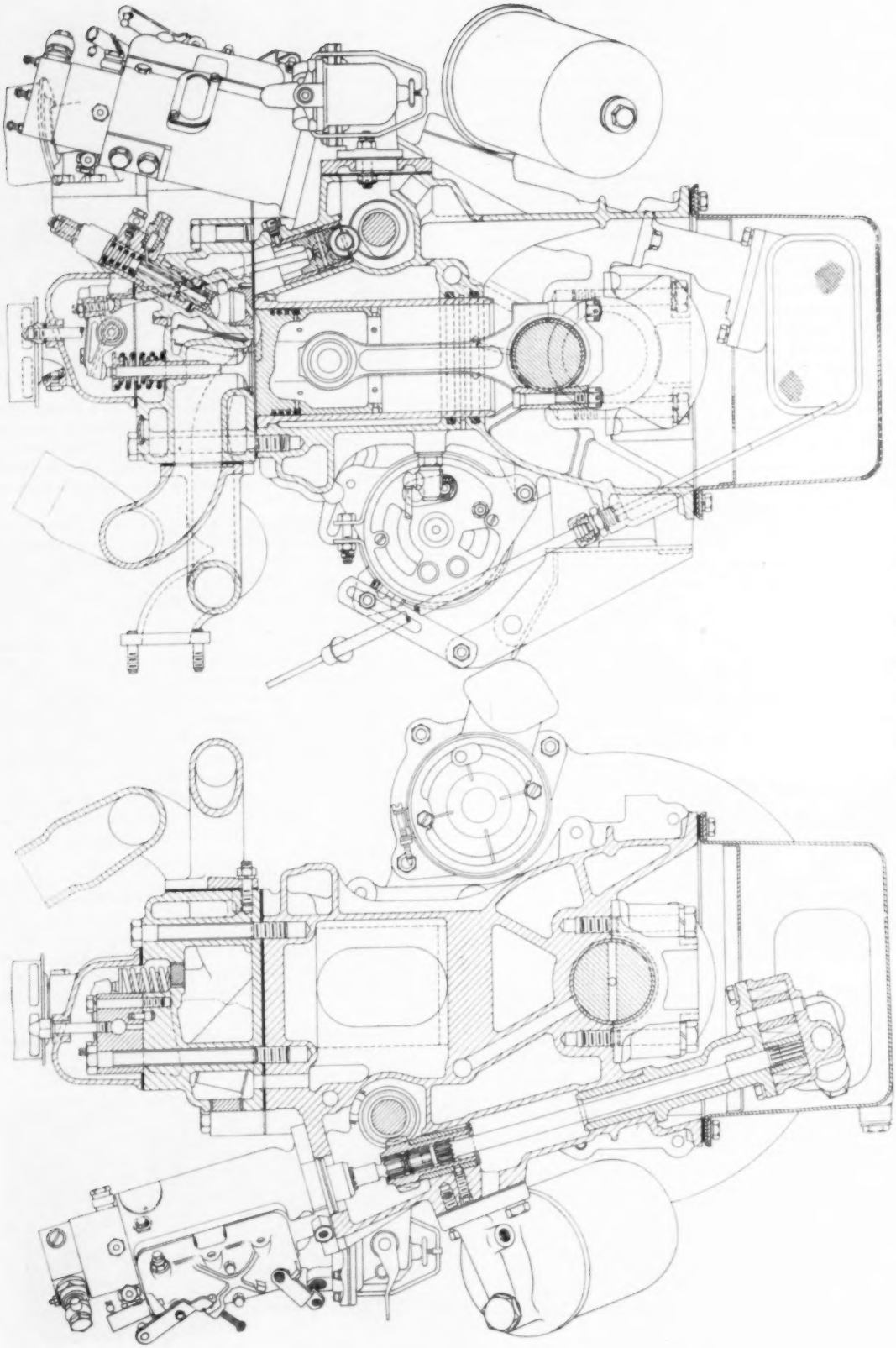


On the original engines, a compression ratio of 19·5 : 1 was used, and the piston crowns had heart-shape recesses joined by a slot, or channel, to the point near the edge of the crown opposite the combustion chamber throat orifice. Some dissatisfaction with the noise level was expressed, so to reduce it, the compression ratio was raised to 22·5 : 1. This was effected by the elimination of the heart-shape recess, leaving only a straight slot in the piston crown. The effect of this modification was to give a more regular rate of pressure rise, but the increase in the compression pressures and the amount of air passing through the combustion chamber throat led to slightly increased pumping losses, with the result that the specific fuel consumption curve, although substantially unaffected at normal loads and speeds, does tend to rise slightly higher at peak speeds and loads than with the lower compression ratio. However, this sacrifice has proved to be worth while, because of the much more acceptable level of noise obtained.

Extensive re-equipment of the machine shops at the Tyseley factory of the Rover Co. has led to the introduction of a transfer line for engine blocks. The major structural difference between the new 2¼ litre petrol engine and the 2 litre diesel is that, whereas wet cylinder liners are fitted on the diesel unit, the larger bores of the petrol engine are cast integrally. With this difference provided for, the block

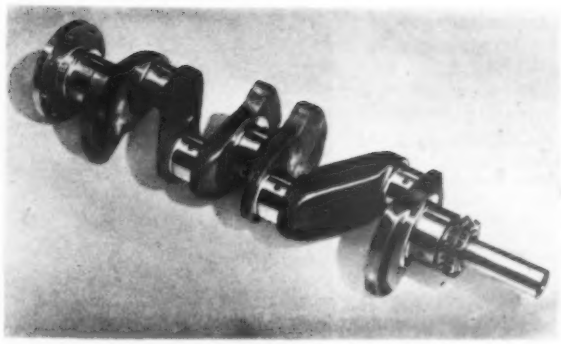
View of a sectioned C.A.V. fuel injection pump, with its centrifugal governor. On the Rover engine, this pump is mounted approximately in the vertical position, as illustrated on the opposite page





CROSS SECTIONS OF THE ROVER DIESEL ENGINE

Bore and stroke $3\frac{3}{8} \times 3\frac{1}{4}$ in (85·7 × 88·9 mm). Swept volume 125·17 in³ (2,053 cm³)



The crankshaft is one of the components that are common to both the diesel and the petrol units. Among the others are the main and big end bearings, timing drive and many of the valve gear components

castings for both types of engine pass down the same transfer line.

The principal components that are common to both engine types include the crankshaft, main and big end bearings, timing drive, many of the valve gear parts, the oil and water pumps and sump.

A B.S. 1452 grade 17 cast iron cylinder block is employed. It is substantially webbed and is extended down well below the level of the crankshaft axis. Although the crankshaft has three bearings, the cylinder bores are well-spaced and consequently there is room for the liner flanges to be completely surrounded by the metal of the block casting. This results in an unusually rigid casting for a wet liner block; the bridges between the cylinders are supported by heavy internal webbing. Set screws or set bolts are used in preference to studs in the general assembly of components such as the cylinder head, main bearing caps, sump, side covers, timing cover and flywheel housing. However, studs are employed at certain points, purely as an aid to location on assembly.

The cylinder liners are of centrifugally cast Brivadium alloy 80 and have plain skirts. At the top is a thick flange, and below it is a spigot, which is located in the block bore, there being a clearance round the flange. At the bottom, the liners are sealed by two rubber rings in square section grooves in the block. A leak groove between the seal grooves is vented to atmosphere. The liners are retained by the cylinder head, and the gasket seals the tops of the flanges. To ensure that the seal is effective, the liner stands 0·002-0·004 in proud of the top face of the block. A normal copper-and-asbestos gasket is used, the turnovers round the cylinder bores being reinforced with an extra thickness of copper at the seatings of the hot-plugs.

Three copper lead-lined steel shell bearings, with a tin overlay, carry the forged crankshaft, which is of En 110 U steel and is counter-balanced. Before it is machined, the shaft is heat-treated to a Brinell figure of 269-310, and there is no further heat treatment. Unusual care has been taken over arrangement of the oilways. The main bearing journals are drilled right through diametrically, and the inclined ducts feeding the crank pins are drilled from the outside of the diagonal web of each pair, being subsequently plugged. These inclined ducts break into the drillings through the crank pins, which are at 67 deg to the plane of the cranks. Grooves round the main bearing shells ensure a constant feed to the lightly loaded side of the big ends. The main bearing journals are $2\frac{1}{2}$ in diameter, the front and centre bearings having a nominal effective length of $1\frac{1}{16}$ in and the rear bearing $1\frac{1}{8}$ in. The diameter of the crankpins is $2\frac{1}{8}$ in and the effective length $1\frac{9}{16}$ in. Thus, with a stroke of $3\frac{1}{2}$ in, there is a generous overlap, of the order of $\frac{9}{16}$ in, between the diameters of the journals and crankpins in this engine.

Axial location of the crankshaft is effected at the centre bearing, where semi-circular washers are located in recesses on each side of the bearing housing. It was considered unnecessary to provide full-ring thrust washers. Both half-washers are prevented from turning by butting on the caps, which are located by dowels. The crankshaft is dynamically balanced, on a Jackson & Bradwell machine, to within 0·3 oz-in at each end.

On the rear flange of the crankshaft, the flywheel is spigoted and secured by eight set bolts. It is located by one dowel. The flywheel is a forging and the starter ring gear teeth are machined integrally with it, no provision being made for renewal of the ring gear. The friction face for the clutch is rolled to provide a durable surface. In production, the flywheel is balanced separately from the crankshaft, and re-balanced with the clutch assembly.

Keyed to the front end of the crankshaft is a torsional vibration damper. This consists of a flanged sleeve on which is a bush carrying a cast flywheel combined with a pulley, and a pressure plate. A recess in the flywheel is filled with rubber, which surrounds the flange on the sleeve and is compressed to a predetermined amount by the pressure plate bolted to the rear of the cast flywheel.

Conventional forged H-section connecting rods, of En 12 or En 15, are employed. Their big end bearing caps are located and retained by the fitted $\frac{3}{8}$ in U.N.F. bolts of KE 805 grade A steel. An oil bleed hole in each big end sprays oil on to the thrust side of the cylinder wall, and the small end is bushed to carry the $1\frac{3}{16}$ in diameter gudgeon pin. The pins are of En 36 steel and are hollow, with parallel bores. They are located in the pistons by circlips.

The pistons are of cast B.S. 1490 LM 13 WP alloy and, apart from the slot in the crown to match the combustion chamber, are plain. Their skirts are ground to an ovality varying from 0·006 in at the lower end to 0·012 in just below the ring belt, and are slightly barrelled. The complete pistons are tin-plated. There are four rings: the top compression ring is chromium plated, the second and third rings taper faced, and the fourth ring is of the slotted oil control type. A fifth groove, for an oil control ring, is provided at the lower end of the piston skirt, but is used only in exceptional cases.

A duplex roller chain drives the camshaft, which is

Generous spacing of the cylinders has enabled the liner flanges to be completely surrounded by the metal of their housings in the block, and this has resulted in an unusually rigid cylinder block casting

fairly high up on the right-hand side of the crankcase. An automatic tensioner sprocket acts on the slack side and a long rubber pad under the taut run of the chain prevents whip. The tensioner sprocket is mounted on what is in effect the plunger of a hydraulic cylinder served with oil from the main gallery. Oil pressure, assisted by a light spring, forces the sprocket against the chain and maintains the tension, and a ratchet device prevents the sprocket from retracting when the oil pressure falls.

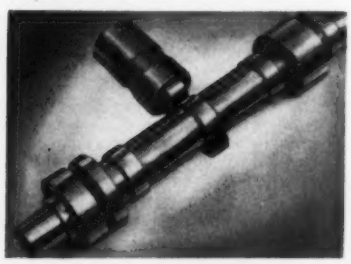
Four bearings, each with a nominal diameter of $1\frac{27}{32}$ in, support the camshaft, which is an En 351A steel forging. They are not equally spaced: the front bearing is immediately behind the sprocket, but the other three are between the cams for the second, third and fourth cylinders, with the result that the rearmost cam is overhung beyond the bearing. Axial thrust is taken by a bronze plate, which registers between the sprocket and the front bearing journal. The camshaft bearings are steel-backed, white metal-lined shells, line-bored in position. They are pressed in and have a 0·015 in machining allowance.

In the design of the cylinder head, careful attention has been paid to the provision of ample water spaces round the valve ports and combustion chambers. The head, which is of B.S. 1452 grade 14 cast iron, is attached to the block by sixteen $\frac{1}{2}$ in U.N.F. waisted set bolts and two waisted studs, all of En 16T steel. Two rows of five bolts each are positioned symmetrically in relation to the cylinder bores, the remainder —four bolts on one side and two bolts and two studs on the other—being on the extreme edges of the casting. Removal of the cores from the casting is assisted by eight plugs; four are of the screwed type, one above each cylinder; two are $\frac{7}{8}$ in diameter expansion plugs over the port gallery; and the remaining two are fitted one at each end. Each of the four screwed plugs also gives access to an almost vertical deflector tube, which directs the coolant flow to the exhaust valve seat. The push rods pass through cadmium-plated tubes, with rubber sealing rings at top and bottom, pressed into the head.

An unusual feature of the valve operating gear is the roller cam followers. The hollow rollers are 1 in diameter and are of chilled cast iron. They float in bronze slippers sliding in slotted, cast iron guides. The slippers have a lead-tin flash on the roller seatings, to accommodate alignment tolerances. Depressions in the upper ends of the slippers receive the ball ends of the push rods. The tappet guides are located in the block by dowel-ended set screws inserted from outside. Solid forged push rods, $6\frac{1}{2}$ in. long, are employed; they are cupped at their upper ends.

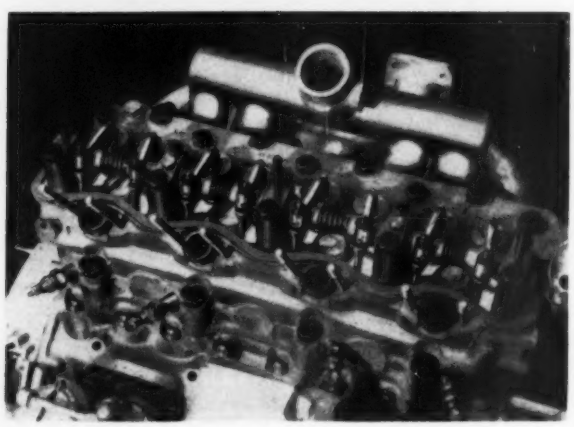
A hydraulically actuated chain tensioner sprocket bears against one side of the timing drive, while a long rubber pad prevents the other side of the chain from whipping

The valves are arranged in the conventional order, that is exhaust-inlet-inlet-exhaust. They are vertical and are carried in cast iron shouldered guides, pressed into the head. The inlet valves are of En 52, and the exhaust valves are of Clyde Alloy SR 822, Brightray faced. An internal groove in the top of each guide carries a Nitrile rubber sealing ring. The valve springs are retained in the usual way by split cone cotters fitting in semi-circular grooves in the valve stems. Double valve springs are used, the inner springs being selected to have an interference fit in the outer springs. The rate of the inner springs is 81 lb/in, and that of the outer springs is 176 lb/in. The valve head diameters are: inlet 1·546 in, exhaust 1·296 in; and the stem diameters are: inlet $\frac{5}{16}$ in, exhaust $\frac{11}{32}$ in.



An unusual feature of this engine is the roller type cam-followers, which float in bronze slippers

The inner ends of the two-piece rocker shaft abut in the central pedestal on the head



A two-piece hollow rocker shaft is employed. The En 32 B rockers are bushed and their end pads are hardened to 56-60 Rockwell C scale. Although the outer ends of the shaft are plugged, the inner ends are not, and they abut in the central pedestal. Five pedestals are employed, and the shaft is located by dowel-ended set screws in the second and fourth ones. This positively sets the position of the oil feed holes to the rockers, which are drilled to take oil to their ends. Each of the five brackets is located by a dowel, and is retained by one cylinder head retaining set bolt and one $\frac{5}{16}$ in U.N.F. set bolt. An external oil pipe is connected to the head, and the lubricant is passed from it through drillings to the rear bracket. The cast aluminium alloy cover is retained by three studs screwed into the rocker shaft brackets.

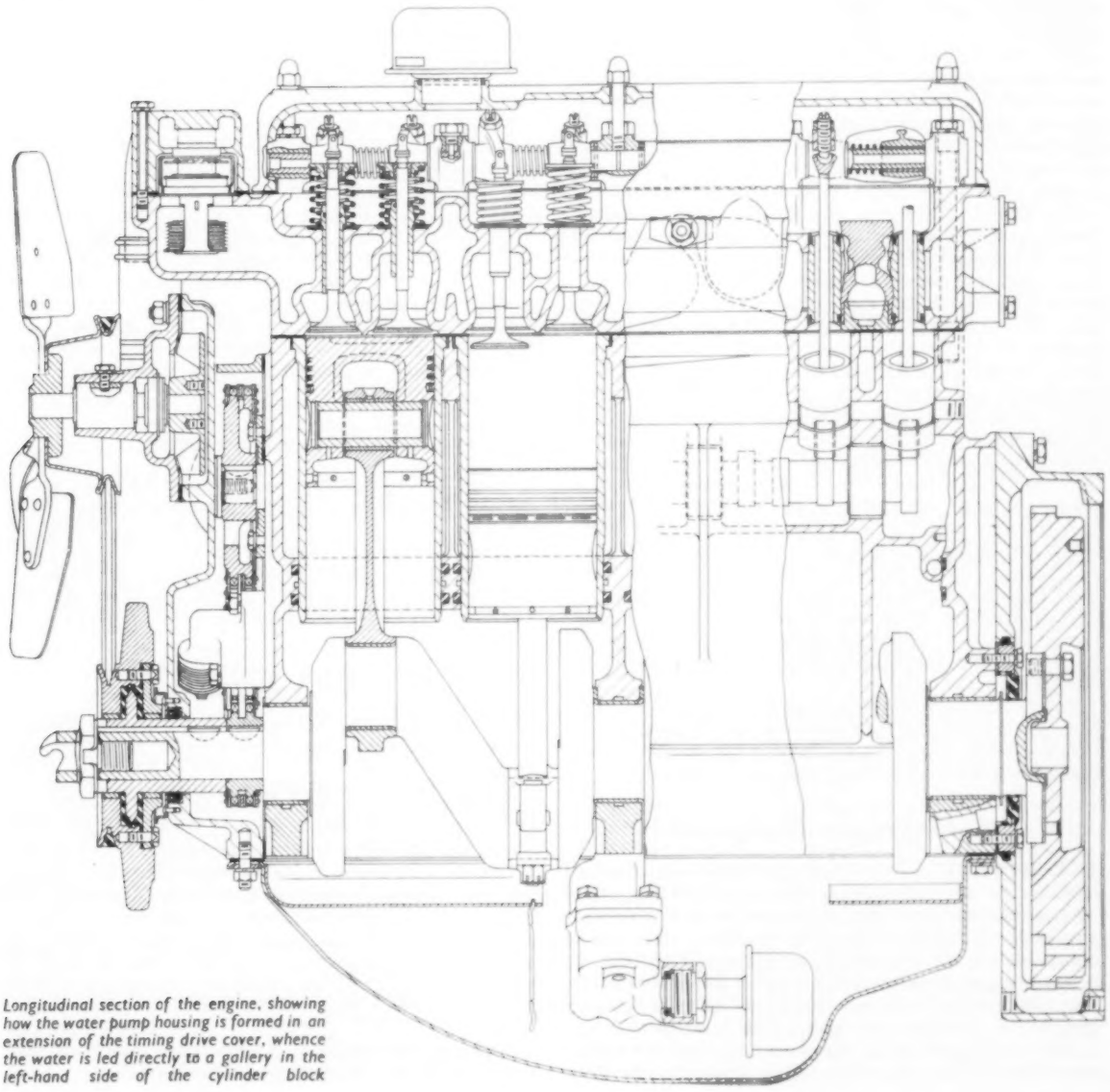
Lubrication of the engine follows conventional lines, but the oil pump and fuel injection pump are driven together by a skew gear on the centre of the camshaft. The driven gear is of En 352 steel, case-hardened to a Brinell figure of 240-270, and it is carried by a split bronze bush. This gear is flanged at its lower end, and the halves of the bush, located relative to one another by four tiny dowels, fit round a journal between gear and flange. The assembly is pressed into the block casting, through the opening for the injection pump, and is located by a ball-ended grub screw with a self-locking nylon insert. Internal involute splines are broached in the hollow driven gear, a blind spline being provided to ensure correct assembly of the injection pump, which is driven by a short loose quill. In spite of the relatively high and fluctuating torque required

to drive the injection pump, no trouble has been experienced, and the indications are that the torque is positive at all times.

A long shaft, with involute splines at its upper end and straight-sided splines at its lower end, drives the gear-type oil pump. The flanged housing for the drive is spigoted in the crankcase and secured by bolts. At its lower end there is a flat face to which the pump body is bolted, the driven gear spindle acting as a dowel. The relief valve is housed in the pump body, and consists of a spring-loaded plunger and ball; the ball seats in the casting, and the plunger provides a progressive opening to the return passage. A plug retains the assembly, and the spring is pre-set to unload at 50-60 lb/in², at normal running speed. A rectangular, convex gauze screen protects the oil intake. Its carrier is screwed into the pump body.

Oil is delivered up the hollow, drive housing and through a drilling in the side of the crankcase to an external full-flow filter. From the filter, a transverse duct leads directly to the main gallery drilled in the crankcase between crankshaft and camshaft. Drillings from the gallery lead to the main and camshaft bearings, and to a second gallery, running above the camshaft, to feed the tappets. From the rear of the main gallery, a duct leads to an external pipe feeding the rocker gear, and from the front, another passage leads to the timing chain tensioner.

The water pump is designed to pass 27 gallons an hour at 3,500 r.p.m. It is of the simplest type, consisting of a proprietary shaft and bearing assembly pressed into a housing, with a proprietary carbon-and-rubber seal unit. The fan hub is pressed on to the front of the shaft and the impeller on to the rear. Studs secure the bearing housing to the pump body, which is formed in an extension of the cast aluminium alloy timing cover. Water is led through a passage in the body directly to a gallery pipe cast in the left-hand side of the cylinder block. The gallery communicates with passages leading to the cylinder head, in the vicinity of the combustion chambers, whence the water circulates through deflector pipes on to the exhaust valve seats. A thermo-syphon circulation cools the cylinder walls. The bellows thermostat is of the double-opening by-pass type. It is housed in a chamber at the front of



Longitudinal section of the engine, showing how the water pump housing is formed in an extension of the timing drive cover, whence the water is led directly to a gallery in the left-hand side of the cylinder block

the cylinder head, and the by-pass passage is connected by a short hose with the pump inlet immediately below. On the vehicle, the complete cooling system is pressurized to 10 lb/in².

Full sealing of the crankcase is a feature of the engine. At the front, the aperture in the timing cover is sealed by a normal lipped rubber seal, and at the rear, a rubber seal bonded to a split cast aluminium housing embraces the crankshaft just in front of the flywheel flange. This latter seal has a shallow double lip. In the front face of the flywheel housing, which is assembled before the flywheel, there is a circular opening grooved internally to receive a sealing ring, which fits round the outside of the split oil seal housing. The sump flange joint is flat, the rear main bearing opening being bridged by the bearing cap, which fits in the rectangular recess with T-shape cork and rubber seals in grooves on each side. Circulation of air through the crankcase is encouraged by two breather orifices, one on the rocker cover and the other on top of a standpipe attached to one of the tappet covers. The two orifices, which are roughly at the same level, are protected by oil wetted steel wool in the breather caps. This sealing and breathing arrangement is necessary for the type of vehicle for which the engine is designed. Apart from the dirty conditions in which these vehicles habitually operate, they are often called upon to perform wading operations, in relatively large depths of water.

Journal for Executives

IN JANUARY, the first issue was published of an important new journal in the field of scientific management. It is entitled *Data Processing*, and covers electronic computers and calculators, punched card machinery and other automatic methods of control. The journal is entirely interpretative in its approach and is designed to meet the needs of top management and administration executives. It describes the latest machinery, including such specialized machines as data-reduction and logging equipment, and analyses current operational practices in a form that will enable executives both to appreciate these methods and to apply them to their own particular problems.

The articles in the first issue include The Computing Service—how it functions and what it offers business and industry; Automatic Reading—a description of the first commercial automatic reading machine, which is to be used to extract information direct from printed cash-register tally rolls; The Universal Language of Computing—a simple explanation of binary numbers, binary arithmetic and decimal binary codes; How an Electronic Digital Computer Calculates—the function of the various units of a computer and a description of how arithmetical operations are performed; Automatic Programming—a simplified technique of programming for electronic digital computers; A Review of Electronic Digital Computers—contains a short glossary of computing terms, an account of the work of the principal manufacturers and details of the computers they build; Wage Accounting and Labour Costing—performed on a punched card system that incorporates an electronic calculator; High-Speed Printing—photo-electric techniques used to print computer output data directly on to the appropriate forms; Industrial Inspection—how modern methods developed in other fields can be harnessed to maintain continuous control of quality.

Data Processing is published quarterly by Iliffe and Sons Ltd., and is obtainable from Dorset House, Stamford Street, London, S.E.1. The price per issue is 25s and the annual subscription is £4 or, in the U.S.A. and Canada, $12.

Molybdenum Disulphide

THE PROPERTIES of molybdenum disulphide as a solid lubricant are now well known, and the material has proved its value in many conditions where normal oils or greases are unsuitable. Originally, as with graphite, molybdenum disulphide was used in flake form, but some years ago the demand began to arise for a powder form suitable for dispersing in liquids. It was then found that the necessary particle size reduction presented a difficult problem.

If the normal milling process is used, the material oxidizes to molybdenum trioxide, which has no lubricating properties. It has been difficult to find other means of reducing satisfactorily the particle size below ¾ micron, and many of the powders available have an average size range between that figure and 3 microns. By the use of ball or roller mills, and suspending the molybdenum disulphide in a liquid, smaller particles can be obtained but the resultant near-colloidal dispersions are frequently less effective than the flake material. This reduction in benefit is thought to be again due to oxidation.

In the Auto-Moly compound produced by Charham Products Ltd., of 5a Market Place, Acton, London, W.3, the average particle size is claimed to be as low as ¼ to ½ micron. This small size is obtained by the use of a quasi-air-flotation method by the manufacturers of the powder, K.S. Paul (Molybdenum Disulphide) Ltd., Great Western Trading Estate, Park Royal Road, London, N.W.10. The process is claimed to give very consistent results, and the graph of particle size distribution shows over 65 per cent below ½ micron size. Moreover, the flake-like structure of the disulphide is not affected, nor is there any significant change in the *p*H value in comparison with other forms.

Specialised Forging

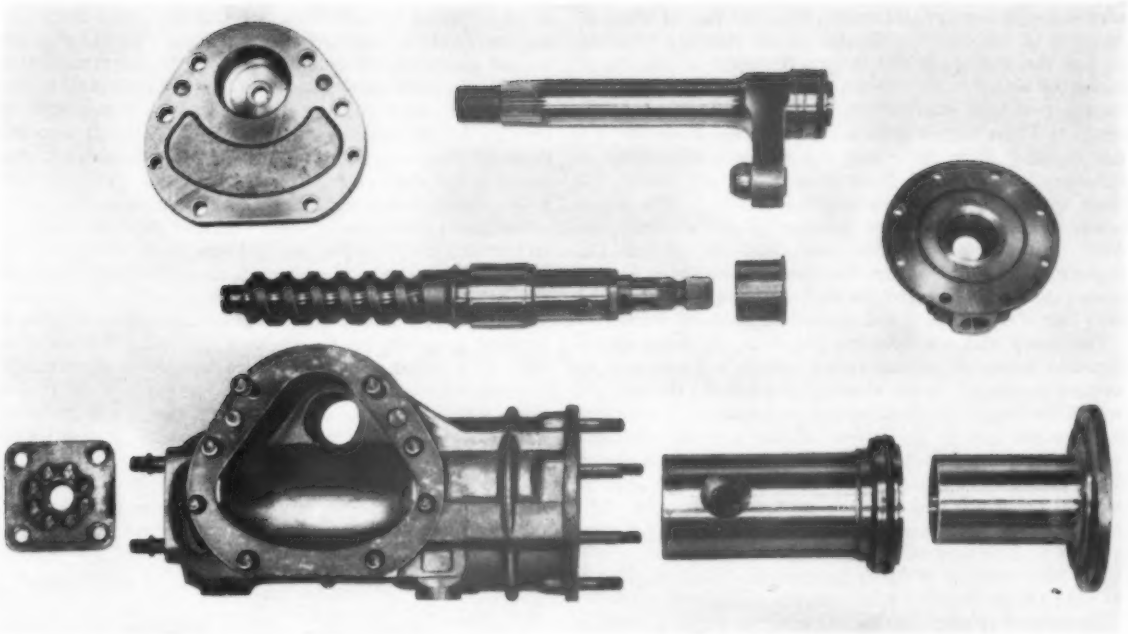
SPECIALISTS in the forging of difficult materials, such as titanium, the Nimonic alloys and the stainless steels, Daniel Doncaster and Sons Ltd. have published a well illustrated brochure covering this aspect of their activities. Its purpose is to indicate the company's resources and experience, and to assist firms considering the application of such materials. The Company's address is Penistone Road, Sheffield, 6.

MIRA Reports

THE following research reports of The Motor Industry Research Association have been released for general circulation:

- 1957/3 Third Report on the Squeal of Drum Brakes.
- 1957/4 Transmission Ratio Requirements for Road Vehicles.
- 1957/5 The Power Losses of Reciprocating I.C. Engines: Some Preliminary Motoring Tests on Two Small Modern Engines.
- 1958/1 The Aerodynamics of Road Vehicles—A Survey of the Literature.
- 1958/2 Intake and Exhaust Silencing—A Collection of Abstracts.

Copies of these reports can be obtained from the Association, at Lindley, Nr. Nuneaton, Warwickshire.



The major components of the Burman FP2 power assisted steering gear laid out to show the basic simplicity and the robustness of the assembly

Burman Powered Steering

Recirculating-Ball System with a Built-In Hydraulic Assistance Unit

TWO impressive 1959 cars, the Jaguar Mark IX and the Armstrong Siddeley Star Sapphire, are equipped with the latest Burman FP2 power-assisted steering gear. The design of this steering gear is based on the company's well-known recirculating-ball mechanism. External hydraulic jacks are not employed to give the servo effect, but instead, the additional power is applied internally. As a result, the installation is compact and robust, and it should prove thoroughly reliable under service conditions. Also, because the degree of assistance is proportional to the effort applied to the steering wheel, the new gear is stated to have good operational characteristics.

The recirculating-ball system was introduced by Burman for production cars nearly ten years ago; basically it is similar to the worm and nut design but has considerably higher mechanical efficiency, the improvement being of the order of 30 to 35 per cent. Machined on the worm portion is a helical groove of slightly less than semicircular section, and having a number of turns appropriate to the requisite number of steering wheel turns from lock to lock. The bore of the nut is appreciably larger than the outside diameter of the worm, and the lower end of the nut is of approximately semi-cylindrical form, its underside having been machined off almost to the transverse diameter. In the semi-cylindrical part of the bore, over the cutaway, is a second helical groove of similar section to that on the worm but of half a turn only. The ends of the groove in the nut are joined by a semicircular transfer tube, which passes under the worm at a reverse angle to the helix.

In the closed circuit formed by the two grooves and the transfer tube is a series of hardened steel balls, which, in this particular unit, are $\frac{3}{8}$ in diameter. When the worm is rotated the balls roll round the circuit and transmit the motion to the nut, with the minimum of friction. A rocker shaft is connected to the nut, to convert the axial motion to part-rotary motion.

The hydraulic servo system is basically very simple. On the nut of the recirculating-ball mechanism is a piston, which operates in a liner in the steering box. A hydraulic selector valve directs oil pressure to one side or the other of the piston, depending on the direction in which the steering wheel is turned. The valve is housed coaxially in an extension of the worm member, and the angular travel of the valve relative to the worm is limited by stops. These stops avoid overloading of the valve mechanism by violent operation of the steering wheel, and enable the vehicle to be steered manually in the unlikely event of pump or pipe failure. In such circumstances, the free play at the steering wheel rim amounts to only 1 in.

Pressure up to 650 lb/in^2 is supplied by an engine-driven Hobourn-Eaton hydraulic pump embodying a flow-control valve. The feed is taken to the lower end cover of the box, which is an LM22W aluminium alloy casting. This lower end wall of the box houses the outer race of a cup-and-cone type ball bearing, which is loaded axially by hydraulic pressure and by six light coil springs housed in blind holes in the cover. The function of this bearing is to carry the lower end of the En 34 worm member, on which is formed the inner race. Axial loading is applied to cater for differential thermal expansion between the worm and the box.

A collar is formed integrally on the worm member immediately above the helix. Its upper face serves as the

inner race of a second ball bearing, the outer race of which is machined in the end of a flanged sleeve clamped between the box and the upper end cover. A spigot on the flange locates the sleeve radially in the box. Above the upper ball bearing, two mild steel bushes are fitted round the worm member. These bushes serve as oil seals. The lower one is a close running fit in the sleeve and the sealing function is performed by an internal flange at its upper end. Above the flange are a circlip and washer, and below it is a collar formed integrally on the worm member. There is appreciable radial clearance between the bush and the worm. Oil pressure from above pushes the flange downwards to seal against the collar, whereas pressure from below causes the other face of the flange to seal against the retaining washer.

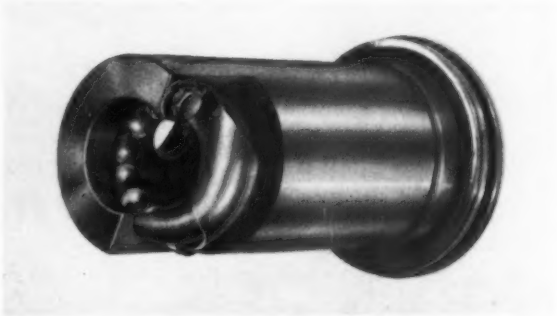
The upper bush is a close running fit on the worm extension, and it has an external flange, which is a clearance fit between the end of the sleeve and the upper end cover of the box. This flange is accommodated in a shallow counterbore in the inner face of the cover. There is radial clearance between the periphery of the bush and the bore of the sleeve. When pressure is applied below the bush, sealing is effected between the flange and the face in the counterbore. The manufacturers have found the sealing bushes to be more effective at these particular points than other means they have tried. Also, because of the radial clearance adopted, there is no need for undesirably close manufacturing tolerances.

En 34 steel is used also for the nut, the upper portion of which is bored out so that it is a sliding fit on the outer surface of the sleeve. Near the upper end of the bore is an annular groove, which carries an O-ring. The piston unit, a hardened steel annulus, is located against an external flange at the upper end of the nut, where it is retained by a washer and circlip. There is a nominal radial clearance of 0·030 in between the bore of the piston and the periphery of the nut. The clearance between the periphery of the piston and the bore of the thin cast iron liner in the box is a maximum of 0·006 in, to suit the requirements of the sealing O-ring carried in an external groove in the piston.

The rocker shaft and arm are a single forging of En 16 steel. Pressed in a hole in the end of the arm is the ball-ended peg that registers in a conical socket machined in the nut. Two bronze bushes support the shaft; the lower of them is housed in the box casting and the upper one in the top cover. Housed in the upper end of the shaft is a plunger, loaded against the cover by two coaxial helical compression springs, the purpose of which is to apply a downward thrust through the arm to the nut, so ensuring firm contact between the recirculating balls and their grooves. Hydraulic pressure, from the main supply, augments this downward thrust, thus ensuring that the total thrust is always correctly proportioned relative to the combined hydraulic and manual axial loads.

An En 34 steel selector valve is employed. It is hardened and ground and is lapped into the bore of the worm member to ensure smoothness of operation. One of its ends protrudes through the upper end cover of the box, in which is housed a Gaco oil seal, and is splined to receive the steering column. Formed integrally on the body of the valve, below the oil seal, is a collar. Two slots are machined diametrically opposite one another in the collar, and into them project dogs formed on the upper end of the worm member. Rotation of the valve relative to the worm is limited by the clearance of the dogs in the slots.

Two pairs of grooves are machined, parallel to the axis of the unit, diametrically opposite one another on the periphery of that portion of the valve which is within the worm member.



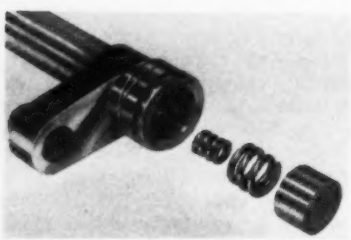
In this underneath view of the nut member, the transfer tube and the ring of balls can be seen. The hydraulic piston is at the right

These grooves are of right-angle section, and there is a thin radial wall separating those of each pair. In the straight-ahead position of the steering gear, the inter-groove walls are in the vertical plane through the axis of the valve. The grooves on the left of that plane are of different lengths but both extend to the lower end of the valve. Since the hydraulic fluid flows up an axially drilled hole in the worm to a chamber below the valve, these grooves are on the pressure side of the circuit.

The second groove of each pair is short and does not extend to the end of the valve. A radial hole drilled from the bottom of each of these short grooves returns the oil from the groove to an axial passage through the valve. The lower end of this passage is closed by a hardened steel plug, against which bears a spring-loaded button, the spring being housed in the chamber just mentioned. From the passage in the valve, the oil flows through three equally spaced radial holes to an annular space in the end cover, between the interrupted collar and the oil seal, and thence to the reservoir.

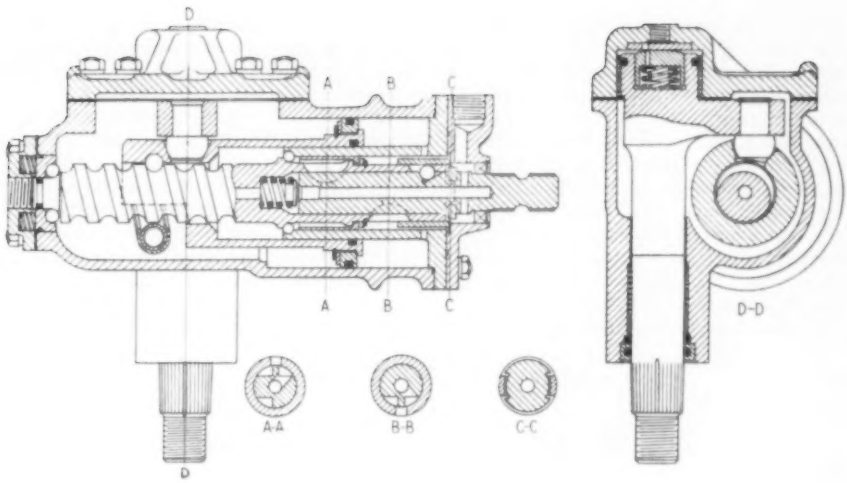
Earlier experimental work revealed a tendency for the valve as described to stick, because of the unbalanced side-thrust of oil pressure on the grooves. In consequence, the valves were modified by the incorporation of a shallow balance groove to equalize the pressure on both sides. This groove is of helical form, to bring its centre of pressure into the right place without excessive reduction of the sealing area round the groove.

In the portion of the worm member embracing the valve,



In the upper end of the rocker arm shaft are housed springs that press the arm down on to the unit

The En 34 hydraulic valve is splined to the lower end of the steering column



This sectional drawing of the FP2 steering gear reveals how the nut is supported on the sleeve. Note also the oil-sealing bushes and the arrangement of the grooves in the valve and nut

two slots are machined. They are positioned diametrically opposite one another but are displaced axially so that one aligns with one pair of valve grooves and the other with the other pair. The slot nearer the worm helix communicates, through the upper ball bearing and the chamber round the worm, with the lower side of the piston assembly. Holes drilled in the main sleeve connect the other slot to the space above the piston.

The width of these slots in the worm member is greater than that of the walls separating the grooves of each pair. It follows that, when the valve is in the neutral position, oil flowing up each feed groove can pass, over the wall, directly into the return side of the circuit, so the pressure is equal on both sides of the piston. However, as soon as the valve is rotated slightly from that position, each inter-groove wall is displaced relative to its slot. This displacement results in a restriction of the flow through the return groove of one pair and the feed groove of the other, so that a pressure differential is created at the piston to assist steering wheel movement.

As the valve travel increases, so does the pressure differential, until one edge of each inter-groove wall overlaps the edge of the slot. Only one return groove and one feed groove are then operative, the others being isolated, and full pressure is applied to the appropriate side of the piston. Slight further rotation of the valve brings the limit stops into operation, so that valve and worm are in direct contact. It follows that gentle movement of the steering wheel will give rise to a small displacement between valve and worm member, and hence only a small pressure differential on the piston; a more forceful movement, on the other hand, gives greater displacement and so more powerful assistance. Although as mentioned earlier, a pressure of 650 lb/in² is available if required, it has been found that the pressure needed in normal driving rarely exceeds 200 lb/in².

Clearly, some means is necessary to centralize the valve when the steering wheel has been rotated as far as is necessary for the required rate of turn. To effect this centralization, the angular movement between valve and worm is made to produce axial movement of the valve, against the pressure of the hydraulic fluid and the spring inside the worm member. Near the upper end of the worm member, an inclined radial hole is drilled, and it is closed on the outer periphery of the member by the upper oil-sealing bush. By means of an end mill, a similarly inclined, flat-bottom hole is produced in the valve. The two holes are not coaxial, and a $\frac{5}{16}$ in diameter steel ball is fitted in the approximately elliptical space formed by their axial displacement.

When the valve rotates relative to the worm member, a wedging or cam action occurs, and this results in the desired axial movement of the valve. It is claimed that the progressive nature of this cam action, and the immediate valve response to steering wheel movement, combine to give a feel that closely resembles that of an unpowered steering system. It is in respect of delayed or over-powerful assistance that certain other servo layouts have been deficient.

As fitted to the Jaguar Mark IX and the Star Sapphire, the FP2 gear has an overall reduction of 20 : 1 in the middle of its range of travel. Because of the increasing lateral component of the movement of the rocker arm, as it departs from the neutral position, the effective ratio rises with the angularity of the arm. Also, because of its direct connection with the arm, the nut is partially rotated as either lock is traversed; in one direction, the nut rotates in opposition to the worm and on the other lock its rotation is in the same direction as the worm. The result is that the ratio rises to 16 : 1 at full lock in the first instance but only to 18 : 1 in the second.

In the unpowered Burman recirculating-ball steering

A cast iron liner in the box casting forms the bearing surface for the piston. All joint faces are amply wide

boxes, the linkage is such that the effective ratio falls towards full lock. This reduces the effort needed for low-speed manoeuvring without giving too indirect a control over the range used in normal driving. The hydraulic assistance has made it possible to employ a basic ratio 20 per cent higher than that of the equivalent unpowered gear; the ratio is now high enough for accurate control at speed without being so quick that the application of excessive lateral forces becomes undesirably easy. Also, since the servo aid eliminates the need for a lower ratio on lock, the lock-to-lock turns of the steering wheel are reduced by more than the change in basic ratio. The difference in gearing between one lock and the other is said to be unnoticeable.

It will be appreciated from the foregoing that the design of the FP2 steering unit shows considerable ingenuity, though it is the ingenuity of simplicity and not of complexity. The mechanism is self-compensating for wear and, though the necessary standard of manufacturing accuracy is high, it is not disproportionately so. Because of the rigidity of the various covers and the adequacy of the joint face areas and of the number of holding-down studs, there should be no tendency for leakage to occur under pressure. A good detail feature in this respect is the feeding of the hydraulic fluid to the closed end of the box; the Gaco seal is sufficient to retain the low-pressure return oil at the upper end. It is worthy of note that equally satisfactory results are obtained with the automatic transmission fluid used by Jaguar Cars and with the low-viscosity engine oil favoured by Armstrong Siddeley.

Television for Vehicle Testing

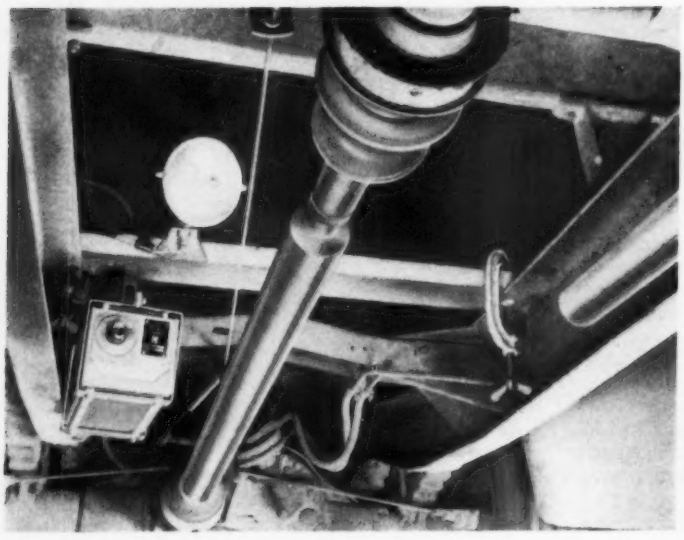
FOR a number of years it has been common practice to use a cinematograph camera to study the behaviour of automobile components under test conditions. Some two years ago Vauxhall Motors Limited introduced the use of closed-circuit television for the same purpose at their test centre at Chaul End, Bedfordshire. This scheme avoided the inevitable delay that occurred because of the need to develop the cinematograph film. However, it was necessary with the closed-circuit television to carry the viewing screen in the car or truck under test, so that not more than two observers could study the results at any one time.

It was therefore decided to develop an open-circuit television system which would enable the receiver to be remote from the transmitter. Since no suitable transmitter was available for this type of work, one was built by the Vauxhall research department. As might be expected, a number of difficulties had to be overcome. For example, no suitable valves were available, and the extremely high frequency allotted by the General Post Office made it impossible to use normal tuning devices. With help from a number of outside firms, however, the transmitter was finally developed and now gives satisfactory results over the short distances involved. Some flutter of the image is still experienced when the transmitting vehicle is moving fast, but this does not preclude accurate observation, and the engineers concerned are confident that they will be able to eliminate it in the near future.

The camera of the set is mounted on the vehicle, close to the component under observation, and is connected to a small transmitter inside the body or cab. On the roof of the vehicle is an aerial which transmits to a receiver aerial on the roof of the nearby research laboratory. This aerial is connected to a normal television receiver inside the building, where the image can be studied by several people at one time. A petrol generator set carried in the boot of the car, or on the chassis in the case of a commercial vehicle, provides the power for the transmitter and for the lamp illuminating the component under observation.

Already the television equipment has proved its value in revealing the cause of intermittent localized vibration on some cars at certain critical speeds. Vauxhall Motors consider that its use will greatly assist them in their current research programme, which includes the study of the behaviour of springs, dampers and propeller shafts.

On the left, the television camera is set up to record the behaviour of the propeller shaft of a commercial vehicle; a spot lamp provides the necessary illumination. In the other illustration, the transmitter unit is being installed in the cab of the vehicle



DISC BRAKES

Part II: Some of the Developments Since the Second World War

J. O. STARLING, M.S.A.E., G.I.Mech.E.

RAPID strides have taken place in the development of disc brakes, particularly those of the spot type, during and since the Second World War. Although at the beginning of this period, much of the emphasis was on more efficient brakes for aircraft, many patent specifications have been directed to the use of disc brakes in road vehicles, particularly of the heavy types. The reason why the greatest advances have been in the design of spot type disc brakes is that heat dissipation is more readily effected with this type of brake than with any other.

Until 1939, most aircraft disc type brakes were of the clutch type, but in 1949, a spot type brake with concentric discs, for aircraft, was the subject of Patent No. 625,726, by the Dunlop Rubber Co. Ltd. and H. J. Butler. Fig. 16 shows two views of the invention applied to aircraft wheels. An outer annular disc A and an inner annular disc B, both of truncated triangular section, have projections A_1 and B_1. These projections engage brackets C secured to the outer and inner peripheries of the annular housing. The brackets are arranged to allow a small axial displacement of the annular disc when the brake is applied. A spider D, having three equally spaced arms D_1, is bolted to a plate E secured to the undercarriage leg F. Each arm carries a pin G_1 projecting through the space H between the discs. Brake pads J_1 are interposed between the inner faces of the arms D_1 and the outer faces of the discs, while similar pads J_2 are interposed between the inner faces of the discs and the acting faces K_1 of the cup-shape sleeves K_2, which slide on the pins G_1 and enclose the cup-shape members L. The brake is applied by admitting fluid under pressure, through a passage G_2, into each pin and thence to the spaces between the members L and sleeves K_2. Brakes of this kind can be adjusted automatically for wear of the brake pads.

An application of spot type disc brakes to motor vehicles was described in 1953, in Patent No. 688,382, taken out by the Dunlop Rubber Co. Ltd., and others. Three views of an embodiment of this invention are shown in Fig. 17. An annular disc, or flange, A is secured to the vehicle wheel B. Straddling a small portion only of the periphery of the disc is a U-section housing member C, which is secured to the non-rotatable portion D of the axle. Three parallel cylinders E contain sealing plungers F and cylindrical pads of friction material G. In operation, when hydraulic fluid is supplied under pressure from the master cylinder system into connection H, the plungers F force the friction pads G inwardly into contact with both sides of the rotating disc. When the brake pressure is released, the residual pressure in the system maintains the pads in light frictional contact with the disc. The extent of friction pad wear is indicated by a projecting rod J.

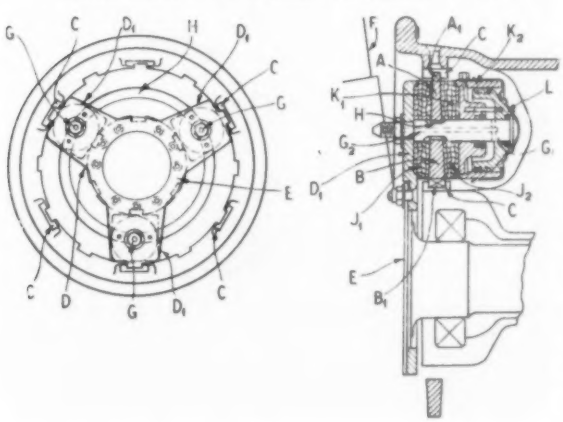


Fig. 16. Two views of a Dunlop spot type disc brake for application to aircraft wheels; this arrangement was patented in 1949

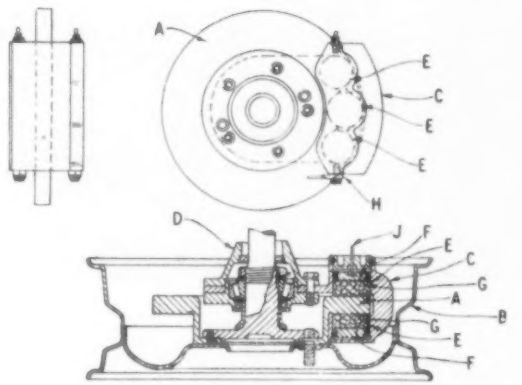


Fig. 17. In this Dunlop disc brake, the extent of friction pad wear is indicated by the amount of the projection of the indicator rod J

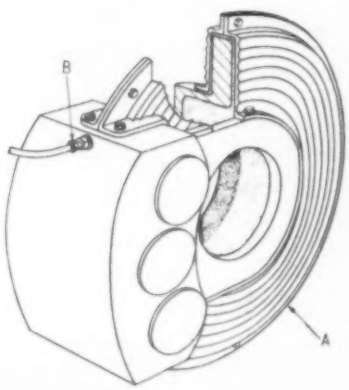


Fig. 18. This Dunlop disc brake patent specification features a casing A to screen the disc from mud

Manufacturers of disc brakes claim that most of the mud and dirt is flung off the disc by centrifugal action. However, Patent No. 693,919, Dunlop Rubber Co. Ltd., shows how the disc may be housed in a protective casing A, which can be ribbed for heat dissipation, Fig. 18. Additional cooling can be effected by air supplied through connection B.

Another Dunlop Patent, No. 690,559, shows a disc brake particularly suitable for heavy motor vehicles, Fig. 19. Pairs of pressure plates A and B, and C and D, carry segmental pads of friction material. They are forced apart by fluid under pressure in cylinders E containing pistons F, until the friction pads bear against the inner faces of the two annular

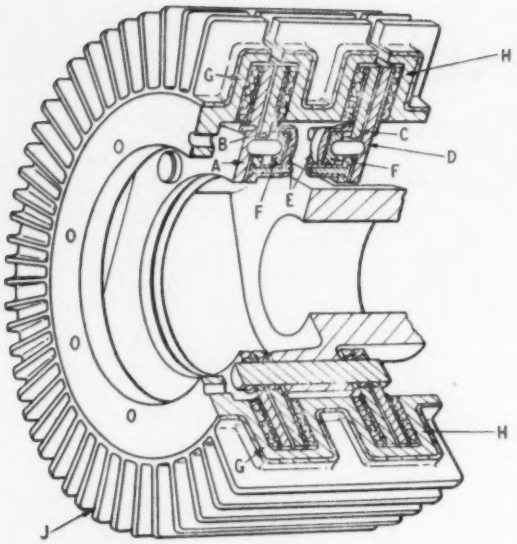


Fig. 19. Left: This disc brake arrangement for heavy vehicles has been patented by The Dunlop Rubber Co. Ltd. The pressure plates are forced apart hydraulically by fluid in the cylinders E

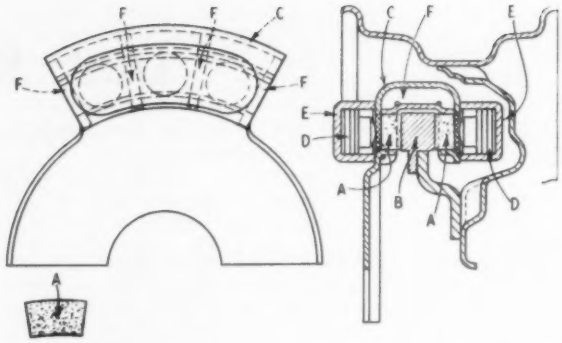


Fig. 22. Above: Segmental friction pads are employed in this Girling hydraulically actuated disc brake arrangement for motor vehicles

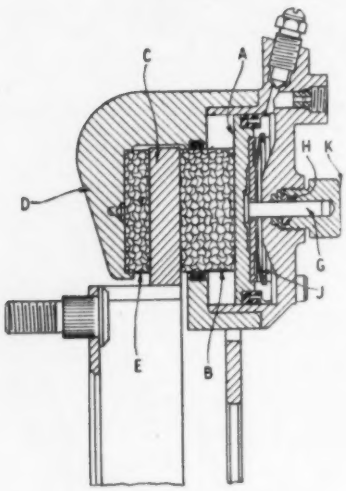


Fig. 24. Right: Dunlop disc brake, as fitted to the Jaguar XK 120C

Fig. 20. Left: Automatic adjustment for wear is a feature of this brake layout of The Wingfoot Corporation, of America

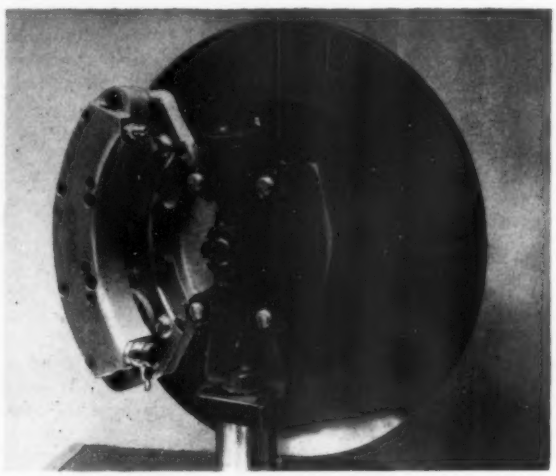


Fig. 21. Left: Girling Ltd. have patented this parking brake for installation on the transmission

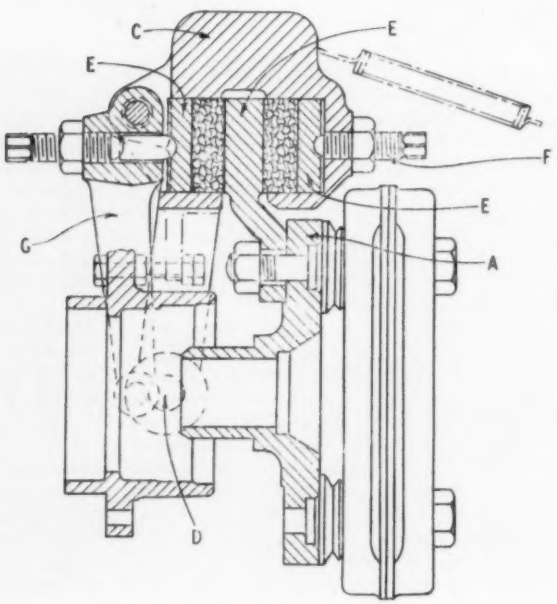


Fig. 23. Right: Electromagnetic disc brake made by The Warner Electric Brake Manufacturing Co.

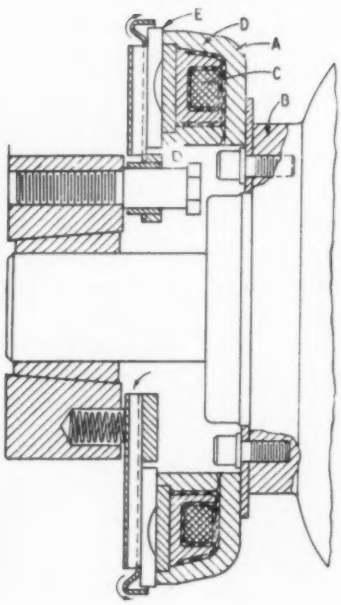
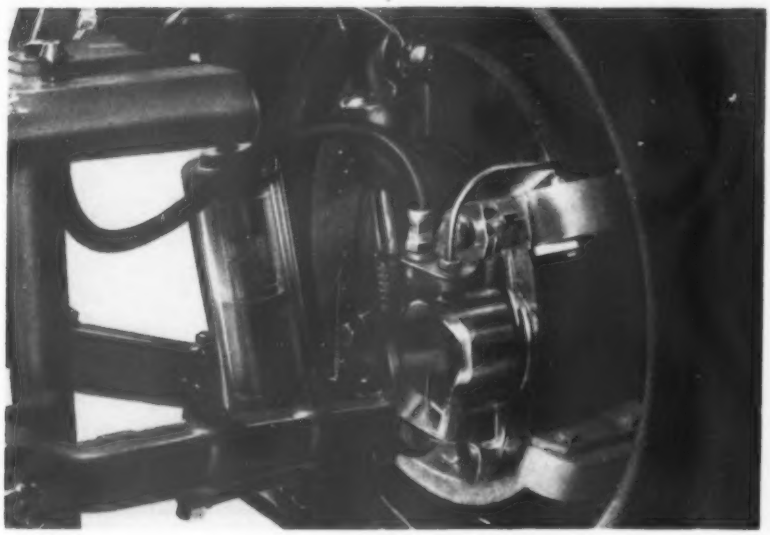


Fig. 25. In the Girling Hydrastatic disc brake, a pair of horizontally-opposed hydraulic cylinders apply the segmental friction pads, one to each side of the disc

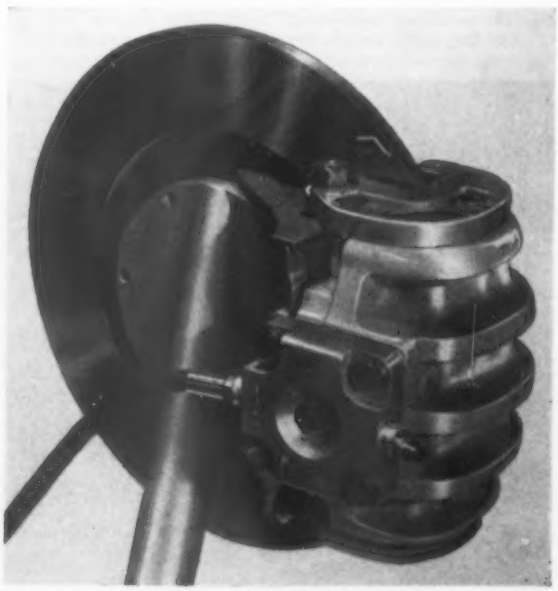


portions G and H of the braking member J, secured to the driving shaft.

Other companies have patented different forms of disc brakes: typical of many filed in this country by The Wingfoot Corporation, of the United States of America, is Patent No. 651,195, illustrated in Fig. 20. This shows a disc brake in which one hydraulically operated piston or plunger A, carried in a stationary housing straddling a part of the periphery of the disc, causes a friction pad B to bear against one side of the rotating disc C. At the same time, the L-shape flange of the housing, which has a pendant leg D carrying a fixed pad of friction material E, is free to slide towards the disc, so application of the braking pressure to the chamber behind the piston A not only moves the piston towards one side of the disc C, but also moves the leg D, carrying pad E, towards the other side of the disc. A rod G acts as an abutment for the piston A in the released position, and a release spring J is normally held relative to the cylinder by the frictional grip of a washer H. The grip of this washer can be adjusted by turning the nut K. When wear of the friction pads takes place, the load in the spring J is sufficient to pull the rod G through washer H to adjust automatically the clearance in the 'off' position.

Some recent patent specifications on the subject of spot type disc brakes include No. 700,579, Girling Ltd. This brake, Fig. 21, is intended for use as a parking brake and is installed on some part of the transmission. A universal assembly A carries the rotating disc. This disc is straddled by a rigid housing C, which rocks about trunnions D. Two holes in the housing receive a pair of plungers E faced at their inner ends with pads of friction material. Both these plungers can slide in the bores, although the right-hand one does so only during adjustment by screw F. The left-hand one can be moved by a lever G coupled to the brake linkage. When this is pulled to the right, the effect is to nip the disc between the two plungers: since the housing is free to rock,

Fig. 26. Two Lockheed hydraulically actuated brakes. That on the left is for application to rear wheels, and therefore can also be actuated mechanically



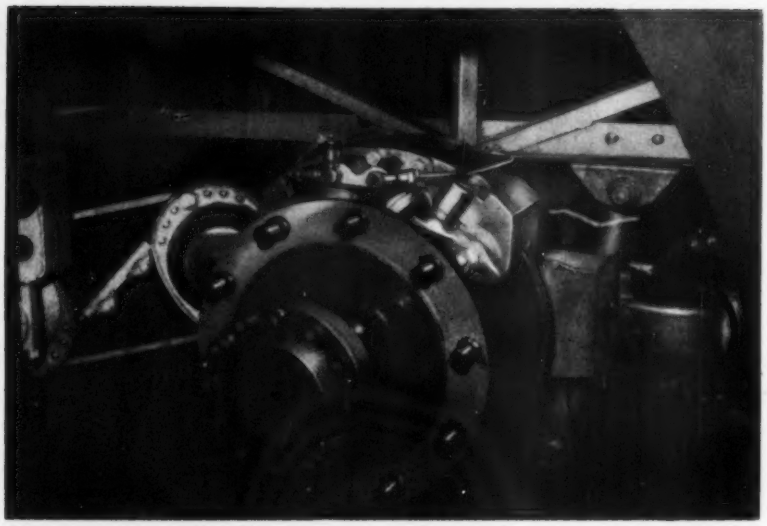
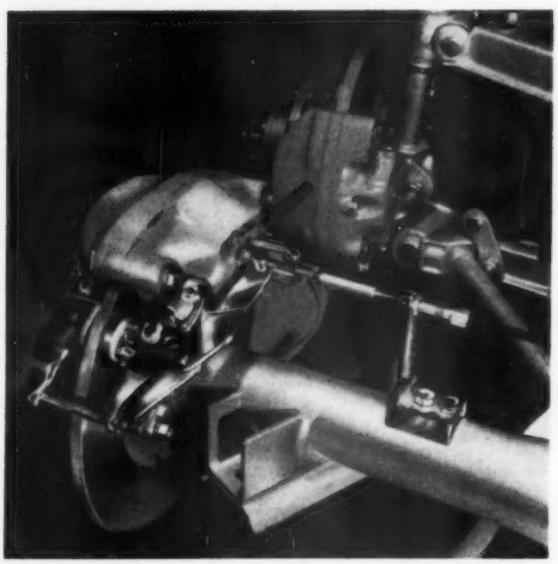


Fig. 27. Left: Girling spot type disc brakes are fitted on this Birmingham and Midland Motor Omnibus Company's S14 bus

Fig. 29. Below: Lockheed disc brakes exhibited at the Motor Show in 1957 have one hydraulic cylinder on each side



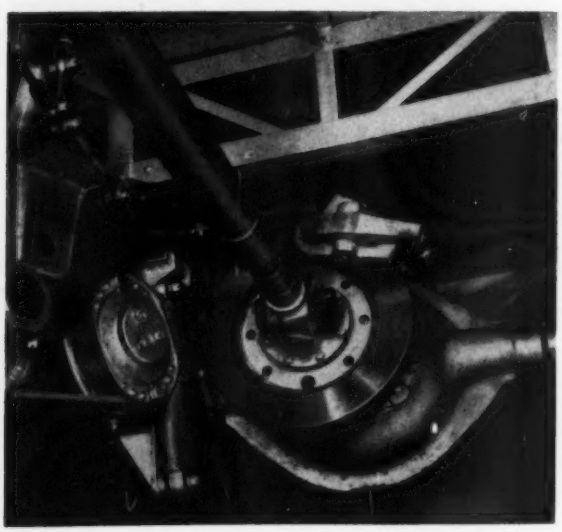
the axial forces on the disc are completely in equilibrium.

Girling's Patent No. 703,213 specifies a hydraulically operated disc brake, Fig. 22, The friction pads A are in the form of segments of a ring of rectangular cross section. They are guided in a direction parallel to the axis of the brake disc B, in a fixed housing C, which straddles the periphery of the disc B. Pistons D, working in hydraulic cylinders E and carried by the housing C, move the pads A into contact with the disc. Radial plates F serve as guides for the friction pads and also help to increase the rigidity of the housing.

As stated previously, recent developments with regard to the clutch type disc brake have been slow relative to the rapid progress made in the development of spot type disc brakes applied to road vehicles. One of the main reasons for this may be that, with a disc brake that is totally enclosed and in which the friction linings extend 360 deg round each actuating plate, it is more difficult to obtain efficient heat dissipation than on a disc brake of the spot type.

An electromagnetic disc brake, Fig. 23, is described in Patent 649,964, Warner Electric Brake Manufacturing Co.,

Fig. 28. A Girling experimental, mechanically actuated, disc type parking brake, suitable for application to the transmission



of the United States of America. The annular magnetic ring A is bolted to a stationary support B. Upon energization of a coil C, disposed between the magnetic poles D, a rotating armature E is drawn axially into contact with the rim of the ring A.

In 1953, the advantage of disc brakes for high-speed motor vehicles was proved in the Le Mans 24-hour race. A Jaguar XK 120C won the race at the then record average speed of 105·85 m.p.h., and similar cars gained second and fourth places. All these cars were fitted with Dunlop spot type disc brakes. Comments made after the race by the drivers of these vehicles and several other competitors confirmed that the saving of valuable seconds on corners, owing to the very efficient braking obtained by the use of these brakes, was a major factor contributing to the success of the Jaguar team.

A few months later, at the 1953 Motor Show, disc brakes were exhibited by some of the leading brake manufacturing companies. Prominent among these were:

1. A Dunlop disc brake, as fitted to the Jaguar XK 120C cars raced at Le Mans, Patent No. 688,382, Fig. 24.
2. The Girling Hydrastatic disc brake, Fig. 25, in which pistons operating in hydraulic cylinders, one on each

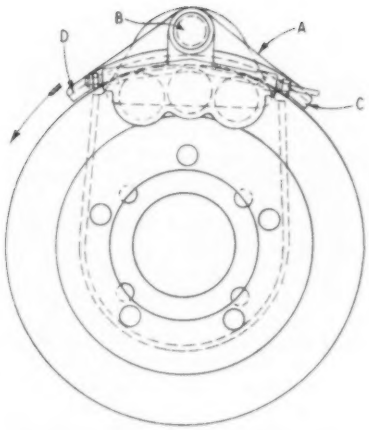


Fig. 34. This brake, by the Bendix Aviation Corporation, is an interesting departure from conventional practice in disc brake design

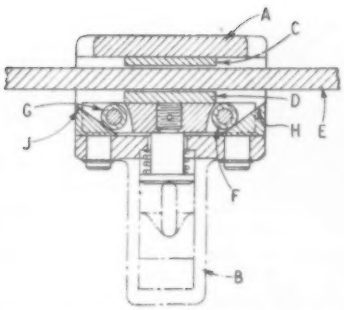
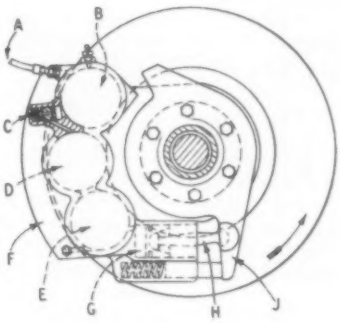


Fig. 33. Above: Coatalen servo type disc brake

Fig. 32. Below: Dunlop servo type disc brake



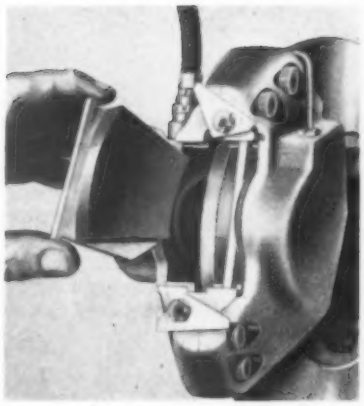


Fig. 31. Above: This Girling brake is designed for ease of replacement of the friction pads after they have worn in service on the road

side of an exposed disc, apply segmental-shape, friction pads against the sides of the disc.

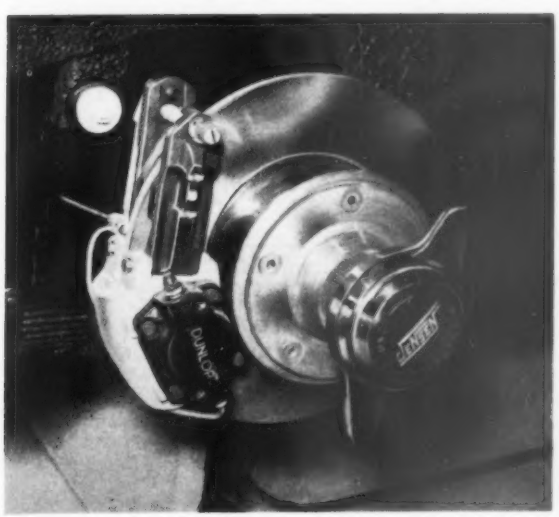
3. Lockheed disc brake, Fig. 26. The illustration shows hydraulically applied front and rear brakes, a vacuum servo circuit being employed. Alternatively, the rear wheel brake can be applied by mechanical means.

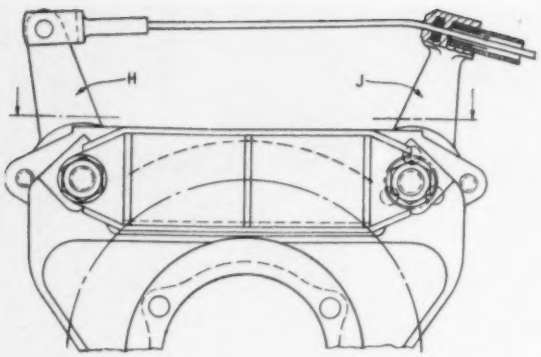
It was announced in 1953 that the Birmingham and Midland Motor Omnibus Co. Ltd. had designed and produced a new bus, the S.14. Among the unconventional features of that design were the Girling spot type disc brakes fitted to the front and rear wheels, Fig. 27. These brakes are hydraulically operated, and the system also incorporates the continuous flow, hydraulic brake servo produced by Automotive Products Co. Ltd. Six hydraulic cylinders are fitted on each of the front wheels, three on each side of the disc. On each rear wheel, there are four hydraulic cylinders, two each side of the disc. A Girling experimental, mechanically operated, disc type parking brake fitted to the transmission of the Midland Red S14 bus, is illustrated in Fig. 28.

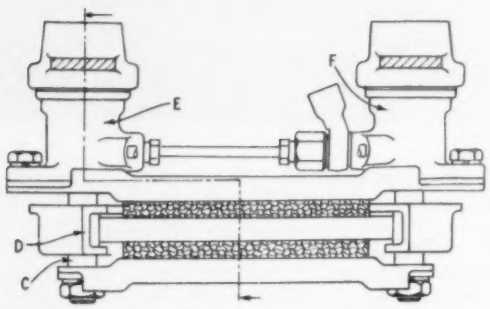
Recent developments

The Lockheed exhibits at the 1956, 1957 and 1958 Motor Show, indicate that they have now turned to disc brakes in which the friction pads are actuated by hydraulic pressure on each side of the disc. Apparently they are abandoning their original conception of applying one pad hydraulically and

Fig. 30. Two Dunlop disc brake arrangements for private cars. Both are hydraulically actuated, but that on the left can also be mechanically operated







using the reaction on the calliper housing to bring the other pad into contact with the opposite side of the disc. Fig. 29 shows the front and rear wheel disc brakes exhibited at Earls Court in 1957.

Girling continue to employ the Hydrastatic principle, keeping the pads in light rubbing contact with the disc when the brakes are inoperative. Dunlop, on the other hand, incorporate retractor mechanisms and automatic wear adjustment devices. Figs. 30 and 31 show respectively some recent Dunlop and Girling designs.

The Goodyear Tyre and Rubber Co. are developing disc brakes of the type in which one pad is hydraulically moved to bear against a ventilated disc. Reaction by the pivoted calliper housing brings the other friction pad into contact with the opposite side of the disc. These brakes are used on the Vanwall Formula I car that was so successful in 1957 and 8.

Future developments

An indication as to the lines of thought being followed by leading manufacturers is given by recently published British Patent Specifications. For example, Patent No. 732,950, taken out by Dunlop, discloses a disc brake with a self-ener-

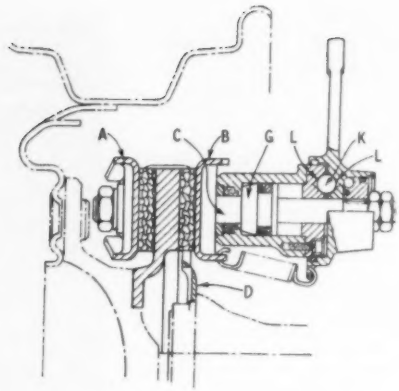


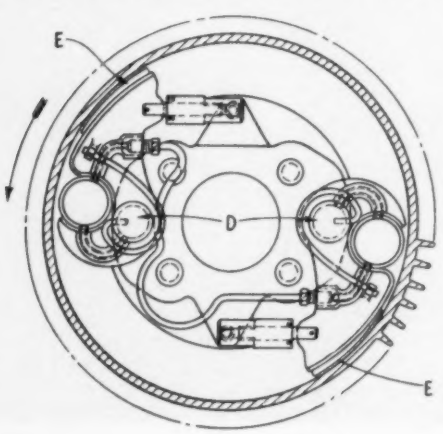
Fig. 36. A disc brake by Alfred Teves Machin und Armaturenfabrik A.G. It can be actuated hydraulically, or mechanically by means of the levers H and J, and the balls and ramps K and L

gizing action. This brake, which is shown in Fig. 32, is actuated initially by hydraulic fluid in the normal manner. The fluid enters through a connection A and actuates and pressurizes the horizontally-opposed cylinders B, thus actuating the pistons and friction pads. As the pressure in cylinder B increases, the sliding valve C is closed and isolates the cylinders D and E. The braking torque is transmitted through the housing F in such a manner that fluid in the cylinder G is pressurized by the reaction through the piston rod H and the fixed lug J. The pressure thus generated in the cylinder G is transmitted to the brake actuating cylinders D and E; this increases the braking torque and, in turn, further pressurizes the servo cylinder G. Thus, the brake pressure builds up smoothly and progressively.

Another self-servo disc brake is described in Patent No. 788,841, taken out by Coatalen, of France. This is illustrated in Fig. 33. The calliper member A floats in such a manner that when the brake is applied, by means of a hydraulically actuated piston and cylinder mechanism B, the friction pads C and D are moved into contact with the disc E. The pad D is free to move to a limited extent with the disc, but when it does so the rollers F or G ride up the cam slopes H or J, so that it grips the disc more tightly.

Girling are among the manufacturers who have taken out patents in respect of means of removing and replacing friction pads easily. This device is described in Patent No. 742,338. From Fig. 31, it can be seen that the pads can be inserted or withdrawn in a radial direction. This illustration is of the type of brake currently fitted to the front wheels of the Triumph TR3.

An interesting departure from conventional practice is



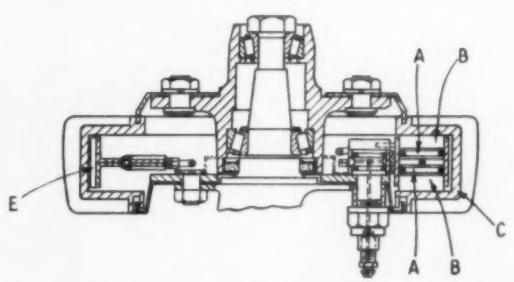


Fig. 35. The Bendix Aviation Corporation have patented this brake arrangement. Initially, the pistons A force the friction pads B against the sides of the housing C, then the brake torque reaction causes the cylinder assemblies to pivot about the pins D until the friction linings E of the shoes come into contact with the periphery of the drum

that described in Patent No. 761,076, taken out by the Bendix Aviation Corporation. In this device, which is illustrated in Fig. 34, application of the friction pads to the disc causes the housing A to pivot about a pin B, and brings one of the brake shoes, C or D, into contact with the periphery of the disc.

This same firm has also taken out patents on the subject of combined disc and shoe type brakes, similar to that described in Patent No. 758,882. In this, Fig. 35, the brake is actuated initially by fluid pressure in the space between the pistons A. These pistons force the friction pads B against the sides of the housing C, which performs the function of the disc of more conventional arrangements. The brake torque reaction acts on the cylinders and causes them to pivot about the pins D, thus bringing the friction linings E of the shoes into contact with the periphery of the drum.

In Germany, Alfred Teves Maschin und Armaturenfabrik A.G., have invented the disc brake described in Patent No. 784,887, and illustrated in Fig. 36. Two pressure plates, A and B, one each side of the disc, carry the usual friction linings. The pressure plate A is secured to pin C, which is free to slide in the fixed carrier D. Each of the two cylinders E and F, to which is secured the pressure plate B, houses a piston G, mounted on a pin C. When hydraulic pressure is applied to the cylinders E and F, the pistons G, together with pins C, are displaced to the right. This causes the brake lining carried by the pressure plate A to be pressed against the brake disc, and the cylinders E and F, together with pressure plate B, are displaced to the left to bring the friction lining carried by the latter into contact with the brake disc. This brake can be actuated mechanically by means of levers H and J, in the left-hand diagram, and ramps K and L, which can be seen in the right-hand diagram. One of the two levers is actuated by the control cable and the other by the casing of the cable, so the forces on them are equal.

Conclusion

It is obvious that disc brakes have many advantages over existing types of drum brakes. These advantages include freedom from fade, stable action, freedom from thermal expansion problems, virtual immunity from the effects of water, self-cleaning characteristics, freedom from trouble due to bedding down after new linings have been fitted, adjustment for wear can be easily affected automatically, and replacement of friction pads can be effected readily. As the demand for this type of brake increases, it should be possible to reduce considerably the overall production costs.

Disc Brakes, Part I

In Part I of this article, the disc brake shown in Fig. 4 is, of course, a Girling unit and not a Dunlop one as indicated in the caption; then the second line on the same page should refer to Figs. 3 and 4, since Fig. 5 illustrates Girling disc brakes, some of which are mechanically and others hydraulically actuated.

With regard to the wiping action of brake linings as mentioned in lines 20-23 on page 11, the essential difference between the disc and drum brakes in this respect is that the dust tends to be retained in the drum, whereas it falls completely clear of disc brake units. In the last paragraph on that page, mention is made of the fact that Dunlop have abandoned the principle of maintaining the pads in light contact with the disc when the brake is off; however, they have of course adopted another self-adjustment device to take its place. On page 14, column 2, line 14, the key letter E, for the centre plate of the aircraft brake, should be D.

Automatic Headlamp Dipping

Electronic Control of the Beam by Means of a Photomultiplier Tube

A VEHICLE lighting development already becoming popular in the U.S.A. is the automatic dipping of headlamps, in response to the light emission from oncoming traffic, by means of an electronic device. The equipment consists of four units: a photomultiplier tube, an amplifier, a power relay and a combination foot switch. Two new photomultiplier tubes for this purpose have recently been introduced in this country by RCA Great Britain Ltd. Designated RCA 6328 and RCA 7117, the tubes are specially designed to provide a stable performance over long periods. They are of the nine-stage type and have a high light sensitivity that permits the use of an amplifier with relatively low-impedance input and fewer stages than are necessary with less sensitive tubes.

The photomultiplier tube unit is mounted on top of the vehicle's instrument panel. A lens picks up light from the oncoming traffic, and this light is focused through a filter and mask on to the actual tube. The tube translates the light into an electrical signal, which is transmitted to the amplifier unit. A light sensitivity adjustment permits the tube to be used with either a clear or tinted windscreen.

Voltage is applied to the photomultiplier unit by the amplifier unit, which also actuates the power relay in response to signals from the photomultiplier. The amplifier valve is designed to operate at an anode supply not exceeding 12 volts, and the coil of a sensitive relay is connected in series between the 12 volt supply and the anode of the valve. Connected to the anode of the photomultiplier tube is a control grid; any variation in the voltage of this grid causes a change in the amplifier anode current, and a corresponding change in the current through the relay coil. When the amplifier valve is conducting sufficient current, the relay armature is held in the high beam position, but when the current falls, the armature is released and the beam dipped.

When the foot switch is in the automatic setting, the amplifier relay is connected to the terminal of the power relay coil. The power relay, a heavy-duty sealed unit, is mounted in the engine compartment. In the dipped beam position of the armature, the 12 volt supply is connected from the dipped beam contact through the armature, the foot switch and the coil of the power relay to earth. Thus, the power relay is energized and switches the headlamps to the lower beam. When the relay armature of the amplifier unit is in the high beam position, the power relay is de-energized and switches the headlamps to main beam.

In addition to providing automatic control in one position, the foot switch also has a position in which the dipped beam is held. When automatic control is selected, however, slight downward pressure on the switch brings the main beam into use regardless of the light intensity received by the photomultiplier. This over-ride allows the driver to signal if an approaching vehicle fails to dip. Street lighting is sufficient to keep the headlamp beams dipped if the foot switch is in the automatic position.

Full details of the RCA photomultipliers, and of the installation and operation of the automatic dipping equipment, can be obtained from RCA Great Britain Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex.

BRITISH COACH BUILT PRODUCTS

Interesting Features of Some of the Latest Custom Built Cars

SOME distinct trends have become apparent recently with regard to British custom built coachwork. Many of the familiar names that we have known for many years have disappeared, as they have also in France, Germany, Italy and Switzerland. Although creative artist craftsmen still exist, names such as Rothschild, Labourdette, Binder, Vanden Plas and Kellner are no more. In British exhibitions we no longer see imposing stands bearing the names of Rippon Brothers of Halifax, Palmers of Dover, Beadle of Dartford, Vincent and Windover. Some of the organizations which bore these famous names still exist, but many are now mainly agents selling popular mass produced cars.

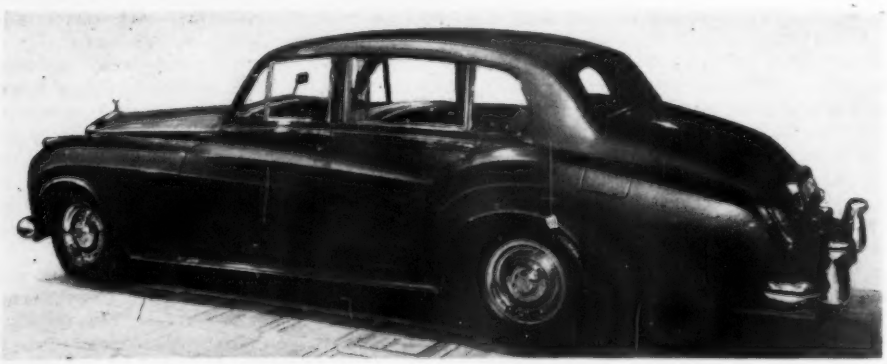
Nevertheless, some firms still produce custom built bodies, as we have always known them: Hooper, Thrupp & Maberley, James Young, Mulliner and others still exhibit at Earls Court, but their activities have altered. The custom built body, made to suit the individual requirements of the purchaser, has practically disappeared. No longer is it possible for the customer to specify his own requirements in respect of such features as headroom and body length: instead, he must be content to accept the external shell of the standard body and to confine his special demands to colour, trim and fittings. In fact, the position in which this section of the industry today finds itself is serious. Labour costs for hand produced components are excessive, and when purchase tax at the 60 per cent rate is added, the gross figure becomes absurdly high.

Coachbuilders are therefore beset with the problem of producing a vehicle at a price that will not be too much in excess of that of the standard vehicle. The luxury items such as calf upholstery, bearskin floor rugs, ivory interior fittings, elaborate electrically operated cocktail cabinets, and specially fitted cases, that were frequently used to appeal to the buyer have been dropped. Even electrically operated window actuators have in many instances disappeared, and manually operated winders and quick-action lever-operated windows by the driver have taken their place. Power actuation has been eliminated on the score of cost alone, whereas only a few years ago, in response to the American trend towards automatic operation of hoods and windows, British cars also were so equipped.

On a recently introduced drop-head coupé, a manually operated hood is offered for the home market, whilst an automatic hood is fitted to the export model, on which there is of course, no purchase tax. People are prepared to pay for convenience, but they will not pay an exorbitant tax for it. In the past, coachwork, no doubt, has often been overloaded with gadgets, adding to weight and complication, but the pendulum appears now to be swinging too far in the opposite direction, and if this trend continues, there will soon be little to distinguish custom built from standard mass production cars. One cannot but applaud the attempts that are now being made to counter this regrettable development.

Standard body shells, produced by the more economical means of mass production, are being increasingly used as a basis for the products of the bespoke coachbuilders. This move was probably inspired by the method adopted to produce estate cars and similar vehicles, utilizing the standard saloon shell up to the middle or rear standing pillar and adding an extension for luggage carrying. Park, Ward and Co. Ltd. now produce a Rolls-Royce Silver Cloud long-wheelbase saloon adapted from the standard shell, in which a division with a drop window is fitted, and the body is lengthened by approximately four inches. The standard

Right: Details of the interior arrangements of the vehicle illustrated below. An electrically actuated drop glass is installed in the fixed division, on which are folding tables and a small cabinet



Left: Rolls-Royce Silver Cloud long-wheelbase saloon, by Park, Ward and Co. Ltd. This body is 4 in longer than the standard version, the doors are larger and rear quarter lights are fitted

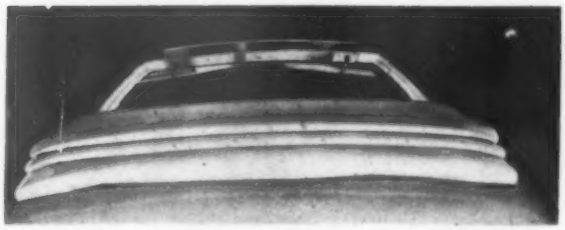
rear door is used but widened by the insertion of a four inch panel welded to the original pressing, and the roof panel is lengthened in a similar manner. All the polished wood panels on the front doors and the dash facia are common to both the standard and the custom built models, and matching panels are made for the rear portion. On the division, there are polished wooden tables and a cabinet, and the trim is of leather, with the usual Park Ward quality finish throughout. The cost of this conversion is £740 more than the standard basic saloon, as produced by Rolls-Royce.

This type of modification has also been undertaken, by Hooper and Co. (Coachbuilders) Ltd., on a Daimler Majestic saloon powered by an engine of 3·8 litres swept volume. In this case the body structure is not altered externally, but a fixed division with sliding glasses is fitted to separate the front and rear compartments. If required, an electrically actuated drop window can be installed in place of the sliding glasses, as also can a folding table below. An additional heater is installed to supply the rear compartment. This type of conversion is popular with business executives, because adequate privacy, for carrying on confidential discussions in the rear, can be obtained simply by raising the glass of the division, whilst the saloon condition, for normal use, can be obtained instantly by dropping the glass. The painting, upholstery and woodwork finishing are carried out in the usual Hooper style and quality.

Among the conversions that occupy a very prominent place are those of Harold Radford (Coachbuilders) Ltd. This company have for some years specialized on this aspect of design, and whilst their output may not be large,

In the Hooper conversion of the Daimler Majestic saloon, there is a fixed division with horizontally sliding glasses. As an alternative, an electrically actuated drop glass can be fitted to the division on demand

the ingenuity they have displayed recently should satisfy even the most exacting buyer. One of their conversions is on a Humber Countryman. The driving seat squab is arranged to fold down to form a couch, and a sunshine roof has been added. This roof panel is not the usual rigid sliding type, which, owing to the considerable roof curvature from front to rear, would not only have been difficult to fit, but also would have allowed only a very small opening. Instead, the panel is flexible and gives a generous opening. When closed, it overlaps the side framing and forms a watertight seal, without the complications of side gutters and drains, which would be difficult to fit to the existing structure. A clear plastics windshield is mounted on the forward edge of the opening to deflect draught from the driver's head and to help to prevent the entry of dust blown up from the road.



The Harold Radford conversion of the Humber Super Snipe saloon has a transparent draught-deflector on the leading edge of the roof opening

The interior of the Humber Super Snipe Countryman by Harold Radford

Harold Radford also offer a Rolls-Royce Silver Cloud saloon, with sixteen special features. Behind the driver, a detachable division, with sliding glasses, can be removed at will in a matter of minutes to form a conventional saloon. A neat detachable neck-rest can be fitted to the near-side front seat squab. One half of the rear seat can be tilted forward to give space for extra luggage, without the risk of damage to the upholstery, which is so likely to occur if cases are placed on the cushion. In the lower part of the front door, a neat recess is provided for twelve standard size bottles. Tables are folded flush with the backs of the driving seats, and there is accommodation for cocktail glasses and flasks below. Equipment for the angler is provided in a tubular case carried below the off-side doors. For short journeys fully assembled fishing rods can easily be carried by pushing them through the sunshine roof opening. The picnic equipment and extending tables in the boot are popular features.

The Ford Estate car conversion of either the Zodiac, Zephyr or Consul is carried out for the Ford Motor Co. Ltd. by E. D. Abbott Ltd., of Farnham. In this instance the standard saloon is employed but it is cut off at the rear pillar, leaving the door structure intact. On the rear of this basic structure is built a luggage compartment with rear quarter lights and a separate door at the back. This extension is built in a special manner, the roof panel being attached to an angled steel framing. Metal and rubber strips are fitted on top of the roof not only to reinforce it to carry luggage, but also to prevent drumming. This latter feature is most important since a structure of this kind would otherwise amplify chassis and road noises to a considerable extent. The tubes of the stainless steel roof rail are loaded with sand and plugged, to eliminate resonance. These measures have proved most successful and the vehicle is as quiet as the standard saloon.

For normal use, the seating arrangement is conventional,

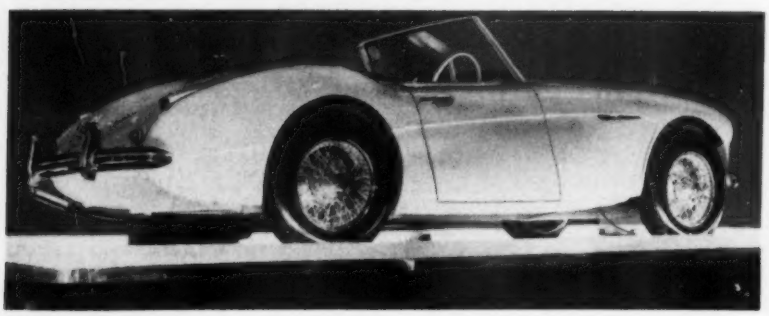
Alvis TD.21 chassis fitted with a body by Park, Ward and Co. Ltd. Although the body style is of Continental origin, production is effected at the Willesden factory

Below: Harold Radford conversion of the Rolls-Royce Silver Cloud saloon. The division is detachable, and its fixing screws can be seen on the pillar at the far side

but the rear seat can be folded forward to increase considerably the space for luggage. A particularly simple device is used to secure the back squab in the normal position: it consists of a ball-ended peg that registers in a rubber socket, which grips the peg firmly and prevents any movement but which is easily detached by a sharp forward pull on the squab. When the rear squab is folded, a rubber covered hook secures it to the back of the driving seat. This detail may appear trivial, but it is essential for these components to be easily and quickly folded and stowed securely. Too often a good scheme is ruined because small slip bolts are used and neither locate the component securely nor remain locked. For export models, a special plastics floor covering is used on the luggage platform and is further protected by metal strips, whilst for the home market a readily detachable plastics floor mat is provided.

Interior of the Austin Princess limousine by Vanden Plas. The angle of the rear seat can be adjusted by means of a small handle just visible on the centre of the forward face of the cushion

Another conversion, also on a Ford chassis, is carried out by Carbodies Ltd. This company have specialized on a series of convertible saloons based on Ford Zephyr, Zodiac and Consul models. The problem in this case involved the provision of a satisfactory under-frame reinforcement to make good the strength lost by the removal of the roof structure of the standard saloon and replacing it with a folding top. On the initial design, introduced a year ago, the standard saloon body was used, but this arrangement was not entirely satisfactory because, owing to the position of the centre pillar, the size of the front door was limited. Also, when the head was used in the *de ville* position, the cantrail came very close to the driver's head. In the latest scheme, this original fault has been overcome, since only the standard floor, dash facia, bonnet top and rear boot lid and dash are used. The wider front door permits the cantrails, when folded, to be well clear of the driver's head, and also affords easier access to the rear seat. Access is further improved by pivoting the driving seat squab in such a manner that it folds slightly inwards as it tilts forward. A small adjustable stop is fitted on the outer edge of the seat



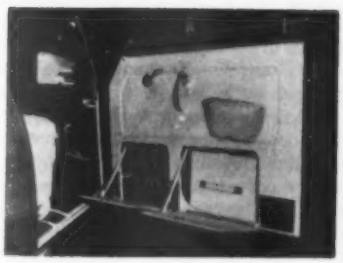
The Golden Austin-Healey 100 Six has been specially finished with gold plated bright parts, interior trim of Chinese kid and champagne mink and with ivory hue paint

frame, so the squab angle can be set to suit the occupant. An added advantage is that the resultant inward inclination of the two squab faces tends to prevent the occupants from being thrown toward the door when the car is cornering. Manual operation of the hood is provided on the Consul, but hydraulic operation is used on the Zodiac and Zephyr. A considerable amount of testing has been carried out by the makers, to confirm that the deflection of the under frame is practically negligible—an essential requirement for any form of drop-head body. The main seam of the hood material is back-stitched and subsequently welded, to ensure that it is completely waterproof.

In the Austin A105 saloon, with special features by Vanden Plas (England) 1923, Ltd., rather more luxury and a better finish than in the standard body are offered. The body structure is entirely standard, with some small external embellishments in the form of motifs on the front wings, the name on the tail and special wheel discs. Most of the interesting features are in the interior trimming and finish. Separate, folding arm-rests are fitted to the front seats, and on the rear seat there is a central arm-rest. The interior polished woodwork is of walnut veneer and resembles closely that of the Princess body. The general standard of comfort and the seating arrangements are excellent. A heavy underfelt is laid under the floor coverings, and every feature of the car is indicative of considerable effort to give the discriminating buyer something better than usual, at an extra cost of only £240, including purchase tax.

On the Austin Princess, no great changes have occurred. This car is a limousine with an electrically actuated drop glass in the division. Two features are of special interest. As can be seen from the accompanying illustration, two hinged foot-rests are provided for the passengers in the rearmost seat. These footrests can be folded against the extra seats if they are not required. When they are folded, there is no obstruction on the floor, as there is when the usual bar-type footrest, pivoting out from the rear heelboard, is used. The second interesting feature is that the rear doors each actuate a switch connected to a small light on the dash, which indicates that the doors are properly closed; this is a valuable feature on a large car frequently used to pick up strangers not familiar with the door closing arrangement. A screw adjuster is provided to vary the inclination of the rear squab, and the division glass rises directly to the head-lining, there being no transverse rail to spoil the appearance of the roof. Although the Princess was introduced first in 1952, various modifications have been made since then, and the current body differs considerably from the original. It is of interest to note that the bodybuilders, Vanden Plas, now build and test the chassis on which this excellent body is mounted. This unusual procedure has proved to be very satisfactory.

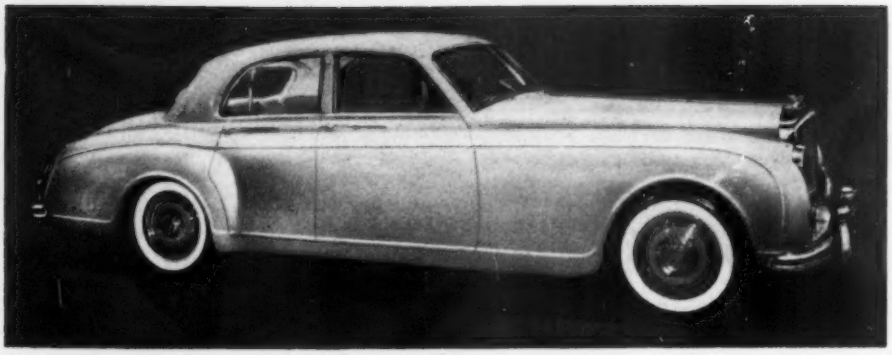
The Golden Austin-Healey 100 Six sports car created almost as much of a sensation at Earls Court as did an earlier exhibit with a similar decorative theme. Jensen Motors Ltd., of West Bromwich, have finished the body with a care and attention to detail that could hardly be surpassed. Once again British craftsmen have demonstrated their adaptability, by combining in a single vehicle the products of a dozen specialists, and creating a thing of real beauty. Obviously the essential practicability of the *décor* does not enter into consideration in such a design. Gold plated bumpers certainly are not ideal for London traffic, neither is Chinese kid a suitable covering for a facia panel likely to be soiled by a mechanic's dirty fingers, or to withstand a sudden rain-storm. The gold anodizing, by Autotints Ltd., is worthy of special mention on account of the almost perfect match obtained between the anodic stain on the non-ferrous parts and the electro-deposited plating on the other details. The price of £4,000 given by the makers as the cost of the vehicle is not important. Its publicity value, especially since it has now been sold, no doubt greatly exceeds this figure. Moreover it is of value to the industry as a whole, in that it shows that Britain can still produce gems of craftsmanship. The car is painted an ivory colour, and the door panels and facia are finished with Chinese kid. It has a steering wheel of solid ivory, from elephant tusks, and the seats are trimmed with rare champagne mink. All bright parts, including the wheels, are plated in 24 ct gold,



Above: Interior of an Austin A105 saloon with a body finish by Vanden Plas. This vehicle has twin centre arm-rests for the two seats at the front

Right: Door arrangement on the Rolls-Royce Silver Cloud saloon by Harold Radford (Coachbuilders)

This estate car is built for the Ford Motor Co. by E. D. Abbott of Farnham. All the main body pressings, except those of the rear extension, are standard components



Clean flowing lines are characteristic of the Bentley Continental saloon by James Young Ltd., of Bromley. An interesting detail feature is the elegant door handle design, which has been chosen to harmonize with the overall styling conception

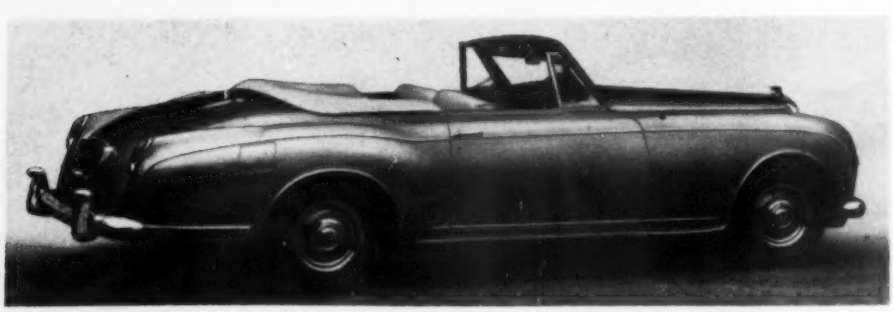
and the ignition key, which carries a scale model of the car, is of solid gold.

Park Ward and Co. Ltd. produce a sports saloon and drop-head coupé on the Alvis chassis. These bodies compare favourably with those made by the same coachbuilder on Rolls-Royce and Bentley chassis. No sign of indifferent or careless work can be detected on models that have been exhibited. Although the styling was done by a Continental designer, the production is essentially British, and considerable thought must have been expended in order to produce it at a reasonable price. The company state that many of the ideas used in construction have been suggested and developed at shop level. They have taken a design in prototype condition and studied the most economical method of producing it, piece by piece, in consultation with the men who are actually going to do the job. The panels are produced on a stretch press, but in many instances simplified tools are employed and the panels are finished to shape and fitted by hand. This has proved to be eminently satisfactory and economical in practice. The framing is built in a light composite construction, panelled throughout in aluminium. Access to the seats is easy and the range of vision good.

A few years ago, H. J. Mulliner and Co. Ltd. produced for the then current Bentley chassis a two-door saloon of revolutionary design. Aerodynamic and other tests were carried out, in co-operation with the chassis builders, to determine the influence that weight and body shape have on performance. It is interesting to note that since the original design was introduced, other coachbuilders have produced versions of Continental Bentley bodies, of both saloon and drop-head coupé type, whilst the original Mulliner bodies are now offered in two styles, standard and special. On the standard version, a fully swept tail is incorporated and the general lines are of orthodox aerofoil form. However, on the new special body, the fully swept tail is altered, the wrap-round backlight is set at a more acute angle and there is a distinct break in the boot profile, to increase the space available for luggage. The finlike extension of the rear wings has rather an American flavour but is quite pleasing. One advantage is that it is now possible to see the tips of the rear wings through the backlight. The wrap-round windscreen affords a good range of vision and the dash facia is curved also and extended to form a hood to prevent reflections of the instruments on the screen at night. On the latest model, the screen pillars have been lightened to reduce the obstruction in the range of vision. Care has been taken to keep the weight to within the limits of the original specification.

Park, Ward and Co. Ltd. also produce versions of the Bentley Continental saloon and a drop-head coupé. The construction is carried out in the Park, Ward patent light alloy scheme, with aluminium panels. Argonarc welding is used because, by obviating the need to use a flux, it produces joints in which corrosion will not develop. The large curved backlight and rear quarter windows on the saloon are improved on the latest model, the quarter windows being extended to leave only a very narrow panel between the outer edge of the backlight and the side light. This further increases the range of vision to the rear. The cushion of the back seat is hinged at its rear edge and can be swung upwards so that the seat pan can be used, in conjunction with a valance extension, to provide a platform for additional luggage. Fitted cases are supplied in the boot, and this gives ample accommodation for luggage. The spare wheel is carried on the floor on the off side, and access to the battery is gained through the boot floor. Tools are fitted into a recess on the near side. Aircraft techniques have been largely followed in the construction of both the saloon and the drop-head coupé. The coupé is a two-door body and is fitted with a manually operated drop head for the home market, and an automatic head for export. Both front seats are adjustable in fore and aft directions and the angles of the squabs, which hinge forward for access to the rear seats, are also adjustable.

Hooper and Co. (Coachbuilders) Ltd. is another manufacturer that has produced a four-door saloon in the Bentley Continental range. This is a new design that incorporates



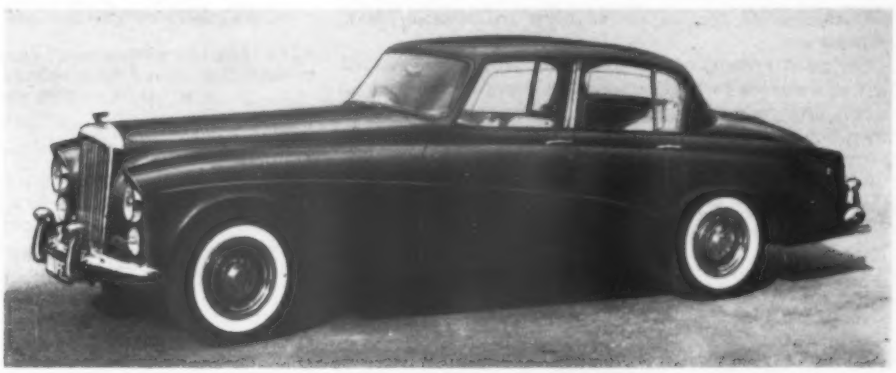
The Bentley Continental drop head coupé by Park, Ward and Co. Ltd. has a manually actuated hood, which folds readily into the tonneau and is neatly concealed by a conventional fabric cover

both steel and non-ferrous alloy framing, with aluminium panels. A feature of the four-door body is the steel central pillar, on each side, which in cross-section has been reduced to a minimum whilst still affording adequate stiffness to the structure. A curved windscreen and backlight are fitted, and the range of vision is adequate, although not quite so generous as that provided on some other makes. Since there are four doors, it has been necessary to incorporate a rear quarter panel of sufficient size to transmit the loads between the roof and the lower structure. A new ventilation feature, in the form of a hinged panel on each rear door, is offered. Above the waist of each of the four doors a Perspex deflector is fitted to the edges of the front pillar and cantrail. Behind these deflectors are the drop glasses, operated by mechanical winders in the normal way. When the glass is lowered about an inch, the slipstream past the windows extracts foul air without creating a draught. On some pre-war cars, deflectors of this type on the cantrail caused wind noise because they projected too far, but the new scheme, since it does not project, has obviated this annoying defect. Reduction of the overall length of this model by four inches, relative to the standard version, has helped to reduce the weight by about two hundredweight. The luggage carrying capacity of the boot is adequate, and although the outline departs from the ideal aerofoil shape, this does not appear to have affected performance in any way.

James Young Ltd., Bromley, produce a four-door saloon on the same type of chassis. A combination of light alloy and steel, with aluminium panels, is employed in a specially light construction. The cushions and squabs are deep and luxurious in the usual James Young style, and are trimmed with golden beige leather. Both front seats are adjustable for both rake and fore-and-aft position. The cabinet work is carried out in figured walnut.

There are several versions of the large seven-seater limousine mounted on the Rolls-Royce Silver Wraith chassis. Among these are models by Park Ward, H. J. Mulliner and Hooper. Basically they do not differ greatly. Electrically operated division windows are a common feature. All seats face forward, and in most instances the rear seats can be adjusted. The finish is almost invariably black. These vehicles still satisfy a need, but unfortunately such a car, complete with chauffeur, is no longer associated with the private user. Probably more than ninety per cent are owned by companies and used for business alone. The high quality of the coachwork is still representative of the finest craftsmanship to be seen today. One interesting model by Hooper has all wool, West of England cloth for the upholstery in the rear part. The striped pattern is of a style that was very popular about twenty-five to thirty years ago; for comfort and wearing qualities, this material cannot be bettered, but amongst the more modern finishes it strikes a somewhat nostalgic note. Ideas discarded for years are often reintroduced and acclaimed as something new, and the very fact that they still find favour is interesting. That design moves in cycles is proved by the fact that the angular body design, popular some years ago, is again beginning to find favour.

Interior of the Park, Ward Bentley Continental saloon, showing the extension of the rear seat pan to provide space for extra luggage inside the vehicle body



Bentley Continental saloon by Hooper and Co. (Coachbuilders) Ltd. The slope of the pillars above the waist rail gives an impression of speed and efficiency. A special feature is the transparent deflector strips at the leading and upper edges of the door windows

This latest version of the Bentley Continental saloon by H. J. Mulliner and Co. Ltd., of Chiswick, is an improvement on the earlier design. Its modern features include the front and rear wing treatment and the wrap-round windscreen and rear light

Flow Meter for Liquid Fuels

Description and Operation of Equipment Embodying a Device for Automatic Refilling of the Measuring Vessel

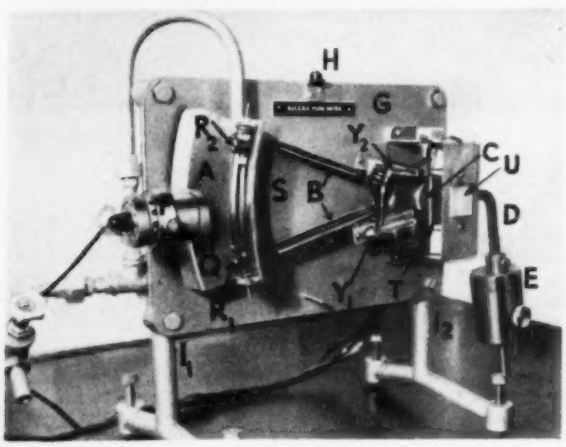
D. N. MacDougall, B.E., A.M.I.E.(Aust.) and K. Weiss, M.E., Dipl. Ing. (Vienna), A.M.I.E.(Aust.)

It is, of course, well known that the fuel consumption of an internal-combustion engine may be found by using a flow meter designed to give direct readings of the rate of fuel flow, or by measuring the time taken to consume a known volume or given weight of fuel. If the volume method is used, the specific gravity of the fuel must be known in order to calculate the fuel consumption rate. There are three different types of direct-reading flow meter in normal use. In the first, the reduction in pressure at the throat of a venturi tube, situated in the supply line, is used to determine the rate of flow. To render the calibration accurate, the fuel temperature must be kept within $\pm$ 5 per cent of a specific figure, and the range of specific gravities of the fuels tested should lie between close limits. An accuracy of $\pm$ 2 per cent can probably be obtained, provided that the fuel head above the float chamber is kept sensibly constant. Instruments employing this principle are only suitable for fuels of the petrol-benzole group, and not for diesel fuels, since the latter suffer from a marked variation in viscosity with temperature, thus making a fixed calibration insufficiently reliable.

The second type of direct-reading instrument employs a float, which is lifted against gravity by the flow of fuel through an accurately tapered and calibrated vertical tube. This float assumes an equilibrium position in the tube, depending on the rate of fuel flow. Such flow meters have been found to give an accuracy of $\pm$ 2 per cent. For the larger installation, special floats can be supplied to obviate the influence of changes of viscosity and density with temperature.

The third system, which is used if small flow rates of fuels or water are to be determined, is based on the laws of viscous flow in small-bore tubes. A direct reading, low-range, liquid flow meter[1] of this pattern has been developed at Queen Mary College, University of London, and in this simple instrument the effect of temperature variations on the viscosity of a fuel is overcome by changing the angle of an inclined manometer. The setting is made with the help of vertical temperature scales, which can easily be calculated for individual fuels or for water. For fuels of different viscosities, allowance can be made by moving the position of the temperature scale horizontally along the viscosity scale. This instrument, it is claimed, has a maximum error of $\pm$ 3 per cent when used for diesel fuel, petrol or water over a temperature range from 50 deg F to 110 deg F.

Fig. 1. General layout of the B.I.C.E.R.A. weighing flow meter, as modified by the New South Wales University of Technology



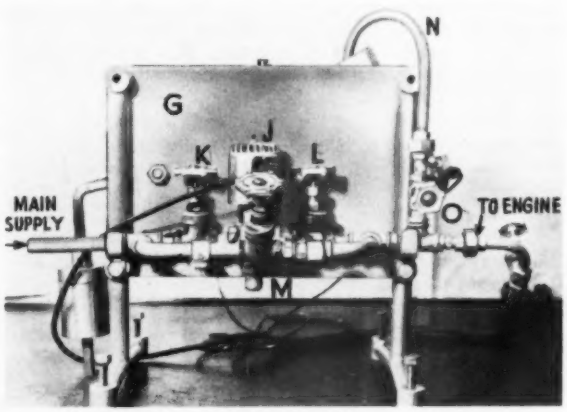


Fig. 2. Details of the fuel supply system for the flow meter, showing the solenoid valve J and the shut-off and by-pass valves, also the syphon pipe N to the weighing vessel on the other side

Instruments used to find the fuel consumption by the volume method incorporate pipettes. The time to consume a certain volume is measured by a stop watch or a tachoscope, and the mean fuel flow rate can then be calculated if the specific gravity of the fuel is known. For tests where a higher degree of accuracy is required, the pipette method is not suitable, since changes in the specific gravity of the fuel and in the volume of the measuring vessel occur if the temperature varies from standard. Another factor that will affect the accuracy of the results is the continuous reduction of the fuel column height above the carburettor during a test run. Temperature corrections, although time consuming, must be made, but the influence of a variable fuel level height cannot be taken into account.

To overcome the unsatisfactory features of the pipette method, the British Internal Combustion Engine Research Association[2] developed for their diesel engine work a flow meter that, in principle, is a weighing mechanism. This instrument was improved upon in a flow meter built for the Heat Engine Laboratory of the New South Wales University of Technology in 1956. A solenoid valve, for the automatic refilling of the measuring vessel, and control board equipment to operate the valve were the most important items added to the original design. With these improvements, the

apparatus proved satisfactory for the rapid and accurate determination of the mean fuel consumption rate. It was found later that the same device could be used to measure with sufficient accuracy, the fuel consumption of a petrol engine.

The redesigned flow meter consists, in effect, of a weighing system, a fuel supply system, an optical system and a control panel. Fig. 1 shows the weighing system, which comprises a stainless-steel weighing vessel A in the form of a segment of an annulus, having a rectangular cross-section. The vessel is supported by two arms B which are welded to a circular boss C. Projecting from the boss is a bent arm D carrying an adjustable counterweight E. The boss is mounted on a horizontal fulcrum pin by means of two small ball bearings, the pin being attached to the vertical back-plate G. A circular bubble H is fitted to the back-plate, which is mounted on two stands I_1 and I_2, fitted with levelling screws.

As can be seen from Fig. 2, the fuel supply system is mounted on two brackets, which are bolted to the back-plate G. The supply system consists of a solenoid valve J, shut-off valves K and L, by-pass valve M, weighing vessel siphon pipe N, its shut-off valve O, and the necessary piping. The siphon pipe has a rectangular plate attached to its open end, the clearance between the measuring vessel and this plate being small in order to provide the maximum damping effect.

The optical system, which is shown in Fig. 1, is based on an electric lamp with a bar type filament, mounted in a tubular holder P. The lamp projects a light-beam through a circular aperture fitted with a graticule Q. Two lenses R_1 and R_2, of short focal length, are mounted in a slide S on the weighing vessel so that their positions can be adjusted. The working setting of one corresponds to the full, and of the other to the nominally empty position of the vessel. When either of the two lenses is in line with the lamp filament and the graticule, an enlarged image of the graticule is projected by a mirror T to a ground glass screen U, marked with a datum line. There is no parallax with this system and the screen may be viewed from any angle. The two lenses have to be adjusted when weighing fuels having different specific gravities, such as distillates and petrol.

On the control panel, Fig. 3, are one 60 watt, 240 to 12 volt transformer V, one triple-pole relay X_1 and one single-pole relay X_2. The relay X_1 is fitted with three sets of contacts, two normally open and one normally closed, while relay X_2 has one set of normally closed contacts. In addition, the panel carries one orange and one green neon indicating

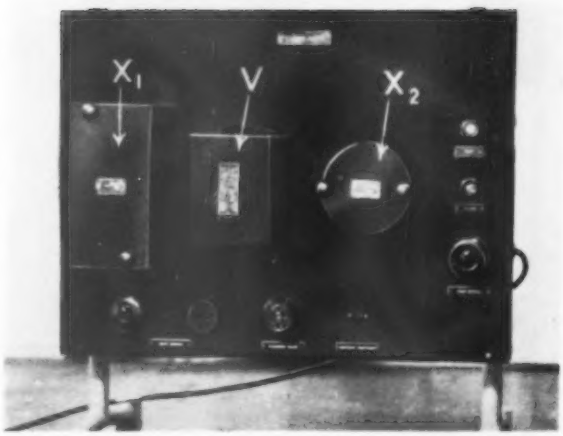
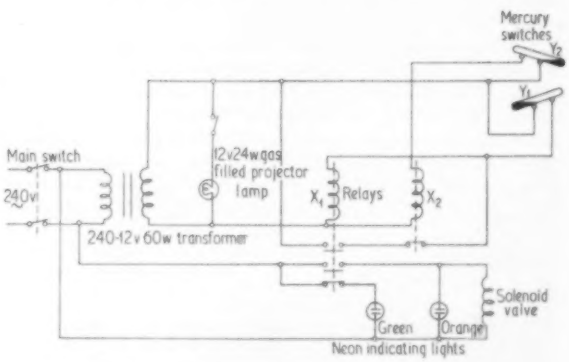


Fig. 3. The control panel carries a transformer V and two relay units

light, and also two switches and two plug sockets used to connect the electrical part of the weighing mechanism to the control panel.

The transformer supplies 12 volt current for the light source and the operating coils of the relays, while the 240 volt supply is used to operate the solenoid valve and the control lights. The orange light serves to indicate that the solenoid valve is open and fuel is being fed to the weighing vessel, whereas the green one is illuminated when the valve is closed. Thus, the flow meter can only be used for fuel consumption tests while the green light is illuminated. The circuit for the control panel incorporates two normally open mercury switches Y_1 and Y_2, Fig. 1, which are mounted on the supporting arms of the weighing vessel in adjustable brackets. Switch Y_1 closes when the vessel is almost empty, leaving a certain amount of residual fuel, while switch Y_2 closes when the vessel is full.

Referring to the circuit diagram, Fig. 4, and the schematic

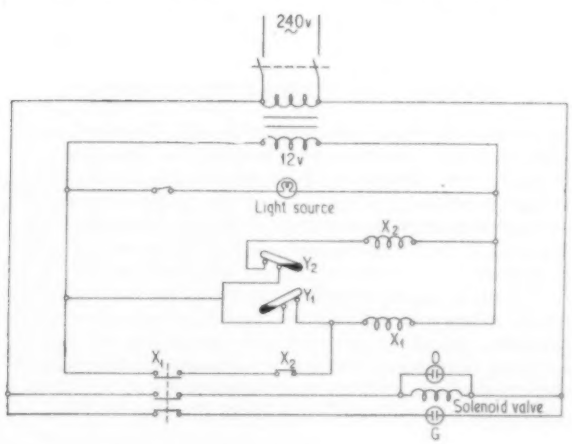


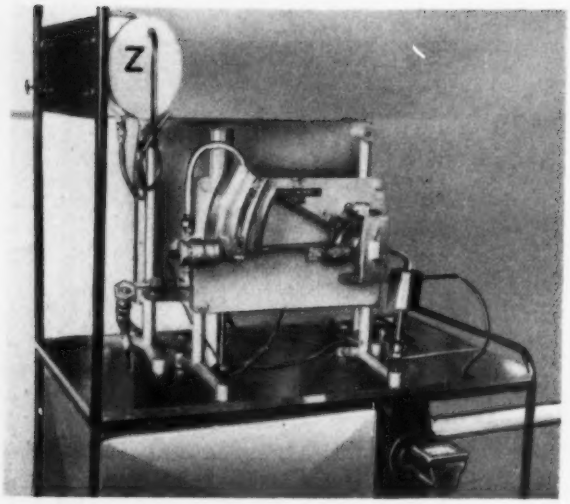
diagram, Fig. 5, it can be seen that, when the mercury switch Y_1 closes, the operating coil circuit of the relay X_1 is energized, closing the two normally open sets of contacts, and opening the normally closed set of contacts. Closing of the first set of contacts completes the operating coil holding circuit, while closing of the second set completes the solenoid valve circuit. Thus the solenoid valve is opened, permitting fuel to pass from the main supply tank Z, Fig. 6, to the flow meter and also to the engine; the orange indicating light is switched on at the same time.

As the weighing vessel fills, the mercury switch Y_1 breaks the circuit, but the operating coil of relay X_1 is now energized

Fig. 4. Right: The electrical circuit diagram for the flow meter

Fig. 5. Below: Schematic diagram corresponding to that in Fig. 4





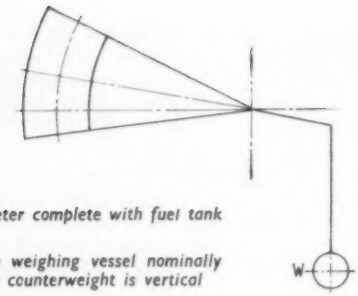


Fig. 6. Left: The flow meter complete with fuel tank

Fig. 7. Right: With the weighing vessel nominally empty, the arm of the counterweight is vertical

by the holding circuit just described. When the vessel has been filled to the required capacity, the mercury switch Y_2 closes and energizes the operating coil of relay X_2, which in turn opens its set of normally closed contacts. This breaks the holding circuit of relay X_1, which is de-energized and returns to its original position, with the green indicating light on.

Mercury switches were selected as contact breakers or contact makers because of their freedom from arcing, an important consideration since the flow meter is required to be used for petrol as well as diesel fuel. A protective coating was used to cover the glass tubes of the mercury switches. The weighing vessel of this meter was sized to hold approximately 1 lb of diesel fuel. This gives a measuring period of about one minute when used for full-throttle tests on a 100 b.h.p. diesel engine.

The weighing system of this flow meter incorporates a modification of the counterweight arm, suggested by B.I.C.E.R.A., in England. As shown in Fig. 7, the arm is bent near the boss through an angle such that, when the vessel is nominally empty, containing only the residual fuel, the portion of the arm over which the counterweight may be moved is vertical. Thus, the fuel level in this position of balance is not affected by the position of the counterweight W on the arm, but only by its weight. With the vessel full, it is therefore only necessary to adjust the position of the counterweight on the arm until the fuel level is the same distance from the top edge of the back plate as in the empty position, which in this particular design of flow meter is 6 in.

The consumption period can be timed by means of a normal type of stop-watch; the recorded time and the known weight of fuel give accurately the mean rate of consumption during that period. A still better approach is to use a Jacques tachoscope, which consists of a revolution counter combined with a stop-watch. The two are set in motion simultaneously by thumb pressure on a catch, and stopped by a similar movement, when the image of the graticule passes the datum line on the glass screen.

After calibration, the meter was checked by carefully collecting in a beaker the discharge between the full and nominally empty settings and weighing the amount of fuel collected. A statistical analysis of the readings obtained with a diesel fuel indicated that the probable error in the weight of the fuel discharge between the set limits amount to $\pm$ 1·3 gm for 1 lb of fuel. This is equivalent to a probable percentage error of 0·3. A similar analysis of the readings obtained from tests using petrol indicated a probable error in the weight discharged of $\pm$ 1·8 gm, which is equivalent to a probable error of 0·4 per cent.

From the results of the calibration tests it is evident that the new flow meter is capable of measuring mean fuel flow rates with a high degree of accuracy, once the weight of fuel contained in the weighing vessel between the set limits is known. The probable percentage errors are negligible, and the only other possible error that might occur is that associated with the timing of the actual flow between the set limits, when the unit is in operation. In addition to its use for laboratory work, the apparatus is equally suitable for making fuel consumption checks in installations of the industrial type.

References

1. J. G. LAVENDER AND C. R. WEBB: "Direct-Reading Low-Range Liquid Flowmeter", *Engineering*, May 1951.
2. W. P. MANSFIELD: "The B.I.C.E.R.A. Flow Meter for Measuring the Fuel Consumption of Internal Combustion Engines", *Mechanical World*, December 1948.

PROOFING TREATMENT

A NEW fluorochemical treatment, known as Scotchgard, has been introduced by the Minnesota Mining and Manufacturing Co. Ltd., Wigmore Street, London, W.1. It is stated that this process, unlike the silicone treatment which resists water-based stains only, gives immunity from staining by oil as well as water. Fabrics, papers and leathers can all be treated, so the process should be of value in the automobile industry.

Staining liquids normally run off the treated surface, and even if they are rubbed or ground into the material they are only forced into the interstices between the fibres. In consequence, the resultant stain is temporary and can be removed with a cloth moistened by a domestic solvent.

REFLEX REFLECTORS

AMONG the many road vehicle matters investigated by the Road Research Laboratory of the Department of Scientific and Industrial Research, is that of the now obligatory reflex reflectors. The results of the Laboratory's investigations have now been published in Technical Paper No. 42, by K. N. Chandler, B.Sc., Ph.D., F.S.S., and J. A. Reid.

The paper starts by defining clearly all the basic requirements of such a reflector and describing the two types available, and goes on to deal with the design and theory. In a later section, standards of performance and the measurement of such performance in practice are discussed. Copies are available, price 2s 6d, from H.M. Stationery Office.

Brake Test Equipment

A Survey of Interesting New Apparatus Now Being Used by Girling Ltd.

IN general, there is only a limited market for brake test equipment, and production has, therefore, been confined mainly to instruments that indicate the maximum deceleration during brake application. However, when brake equipment is being developed, it is necessary to determine as accurately as possible both deceleration and stopping distance. Furthermore, a complete record of deceleration, distance and pedal effort, related to a time base, is very helpful in the examination of brake behaviour. Another important aspect about which precise information is required is the distribution of braking between the wheels of the vehicle under test.

Girling Ltd., of Tyseley, Birmingham, have recently acquired a number of instruments by means of which brake behaviour can be extensively analysed. They are a Peiseler fifth wheel, an Askania recording decelerometer and a set of Peiseler wheel slip counters. This apparatus, which is widely used on the Continent, is hand built so that special features can be incorporated to suit customers' requirements.

The Peiseler fifth wheel provides a record of stopping distance, initial speed and pedal effort, against a time base graduated in $\frac{1}{4}$ sec divisions. All readings are duplicated on visual gauges so that braking efficiency can be studied during the tests. The apparatus comprises the wheel and a separate instrument box, which is compact enough to be stowed, for example, behind the seats of sports cars. A 6 ft flexible drive transmits the motion from the wheel to the instrument box. This length of drive is the maximum permissible if wind-up is to be avoided so, when the instrument is used on commercial vehicles, the wheel must be towed close to the cab.

Illustrated in Figs. 1 and 2 are the wheel and instrument. The wheel is held between tubular forks, the head of which swivels and hinges on top of the support strut, which is a substantial member and is usually mounted on the bumper over-rider bracket. This arrangement gives rigid location, but Girling are exploring the possibility of using a quick-action clamp. Wheel hop is prevented by a low-rate coil spring in tension between the forks and the mounting bracket. Tests up to 100 m.p.h. have shown this system to be entirely satisfactory.

The tyre is bolted to the wheel rim so that it will not creep, and it is inflated until the correct radius, measured by a plunger on the forks, is attained. As an additional precaution, the wheel is run over a measured 100 ft, and checked against the distance meter.

Fig. 2 shows the instrument box and pressometer. On the facia the dials, from left to right, are pedal effort gauge, speedometer and distance meter. For testing purposes, the pressometer is hydraulically coupled to the pedal effort gauge and clamped to the brake pedal. Pedal effort, distance, and time at $\frac{1}{4}$ sec intervals, are traced on the wax recording paper visible through the window at the centre of the upper portion of the facia. The movement of the paper is governed by a toothed roller engaging in perforations and driven by the fifth wheel, through the flexible drive and gears. This drive incorporates a clutch, so that the movement of the paper can be stopped when testing is not in progress. Pedal effort is recorded by a pen controlled by a Bourdon tube actuated mechanism connected in parallel with the gauge on the facia. Distance is recorded by deflecting a pen, about $\frac{1}{16}$ in from its normal path, for the duration of the period of application of the brakes. Timing marks are traced by a solenoid controlled pen, the solenoid current being interrupted by a clockwork timing mechanism. The electrical supply must be 12 volts D.C. and it is usually taken from the vehicle battery.

On the side of the instrument box, there are two connections for the flexible drive: one is for use at speeds up to 100 m.p.h., and the other for speeds up to 50 m.p.h. When the drive is connected for the smaller speed range, the readings are obtained more accurately.

The paper traverse and timing switches are closed about a second before the brake is applied; this permits evaluation of the speed immediately before the brake application. All the instruments that require tripping or starting are automatically operated by a switch actuated by the pressure in the pipe line to the pressometer. Since this switch is closed only when the pressure on the pedal, as indicated by the pressometer, reaches a value of 8 lb, there is a delay of $\frac{1}{16}$ sec, equivalent to a 2·75 ft error at 30 m.p.h., between the initial movement of the pedal and the operation of the instruments. To reduce this delay, Girling intend to

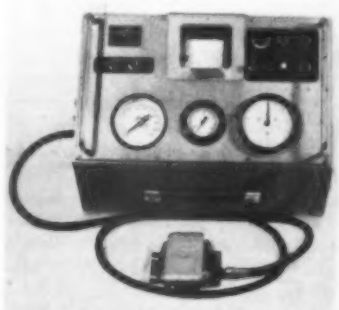
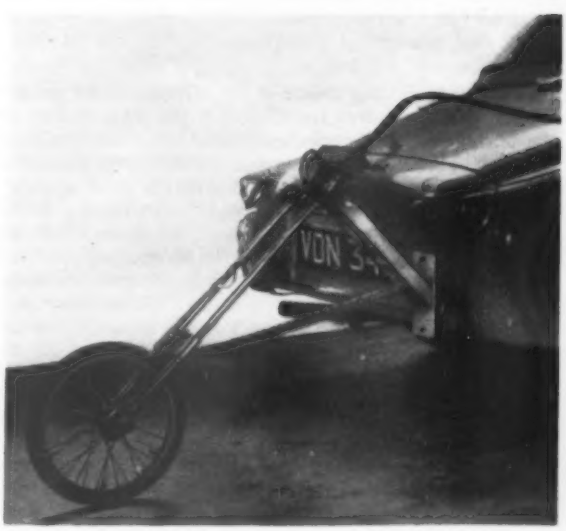


Fig. 2. Right: The pressometer, together with the instrument box with dials showing pedal force, vehicle speed and distance

Fig. 1. Below: Peiseler fifth wheel, mounted on the rear end of a Triumph sports car



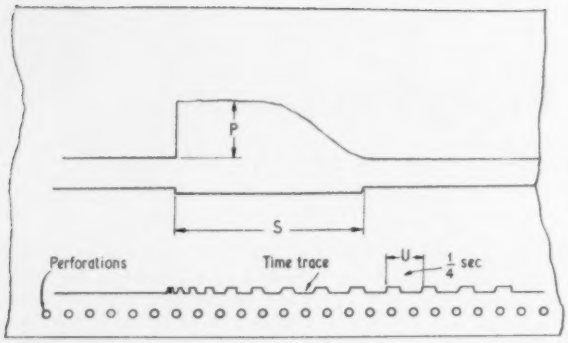


Fig. 3. Recording made with the fifth wheel instrumentation; braking distance of 71 ft, pedal effort of 96 lb and initial speed 38 m.p.h.

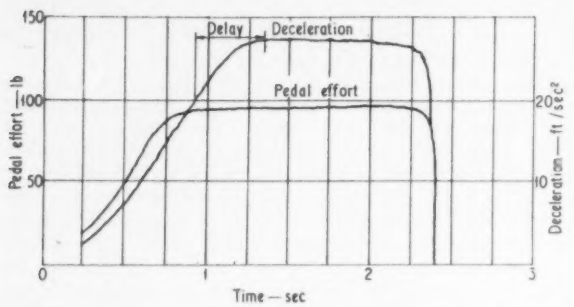


Fig. 4. Deceleration curve deduced from the trace shown in Fig. 3. Deceleration: average 21·3 ft/sec², max. 27·4 ft/sec²; delay 0·45 sec

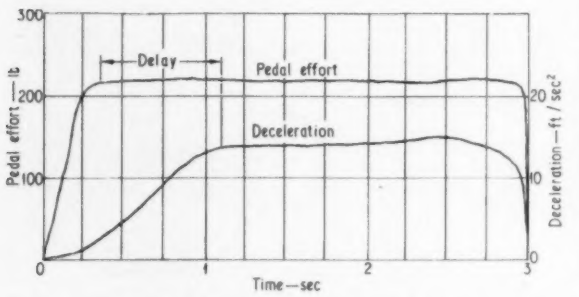


Fig. 5. Curves for a bus chassis with servo assisted brakes. Deceleration: average 9·7 ft/sec², max. 15·0 ft/sec²; delay 0·72 sec

incorporate an electric switch in the foot-pad of the pressometer. All instruments are tripped at the same instant, so the initial speed is accurately recorded relative to stopping distance. This, of course, is a most important requirement so far as the accuracy of tests of this kind is concerned.

When the pressure switch closes, the speedometer on the facia is locked, so as to record the speed from which the vehicle is braked, the distance meter comes into operation and the distance pen is deflected. Since the speed of movement of the paper is proportional to that of the fifth wheel, the distance between the timing intervals grows less as the vehicle approaches rest. This incremental change is directly proportional to the distance change, and hence by differentiation, velocity and deceleration, can be deduced. Evaluation of deceleration takes several minutes, and the last few points on the plot may be scattered, owing to errors of measurement as the distances between the timing marks approach zero. For this reason, the Askania decelerometer is preferred for some applications in test and development work.

Typical records of results of a test are reproduced in Fig. 3. Evaluations of the ratio of average deceleration: maximum deceleration, and the time delay in operation of the braking system, are shown in Figs. 4 and 5. Emphasis is laid on the relationship between average and maximum deceleration, because this is a factor that influences stopping distances. The ratio of these two is affected by the skill of the test driver in applying his brakes, since it is difficult to attain quickly the optimum braking effort and to hold it for several seconds without locking any of the wheels. To eliminate variations, due to the human factor, in the test results, a pneumatic plunger is used to apply the required pedal effort.

The Askania recording decelerometer, Fig. 6, is a neat, compact unit, which can be used for measuring deceleration or acceleration. For vehicle testing, it must be placed approximately level on the floor between the observer's feet; it can be used either on its own, or in conjunction with the fifth wheel apparatus to permit correlation of the independent recordings obtained. The recordings of the Askania instrument are traced on paper ejected from the side of the casing, and a direct reading can be obtained by viewing the trace through a transparent graduated scale.

This instrument works on the spring-mass principle, movement of the mass being amplified by means of a lever system operating a pen. Four vertical leaf springs support the 12½ lb mass and restrict the movement to one axis only. The motion is damped by pressure build-up in a rubber bellows between the mass and the back of the casing, the bellows being sealed except for a small air bleed, in the form of a carburettor jet. This damped spring-mass system has a natural frequency of 5 c/sec. The stylus and its amplifying mechanism are mounted at the top of the casing, and the push rod from the mass can be clipped into any one of four holes in the stylus lever, giving the amplification ratios, AF, shown in Fig. 7.

Two of the ratios are very close, and a full-scale deflection of 40 mm is obtainable at 1g, 0·4g and 0·2g. The stylus can be positioned anywhere on the paper by rotating a knob at the bottom of the case. This knob is on a screw, which adjusts the initial position of the mass. A cam stop must be turned to match whatever amplification ratio is being used. This limits movement of the mass and so prevents the pen from overshooting the edge of the paper.

Movement of the paper is effected by a clockwork mechanism which runs accurately for 1½ minutes, its full running time being 2 minutes. A choice of speeds—30 or 10 mm/sec—is obtained by rotating the drive roller through 180 deg. Movement of the paper is begun or stopped manually by a cable actuated plunger, the cable being clipped to the front of the case. A time base graduated in one-second periods is traced by a pen operated by a solenoid interrupted by

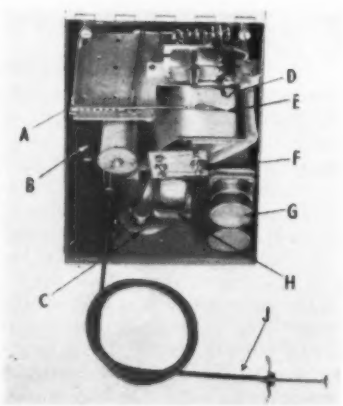


Fig. 6. Askania instrument with the front cover removed to show the principal components inside it

A *lever mechanism;* **B** *spring support for mass;* **C** *cam limiter;* **D** *timing stylus;* **E** *stylus;* **F** *paper drive;* **G** *battery holder;* **H** *winder key for clockwork mechanism;* **J** *cable control for paper transit plunger*

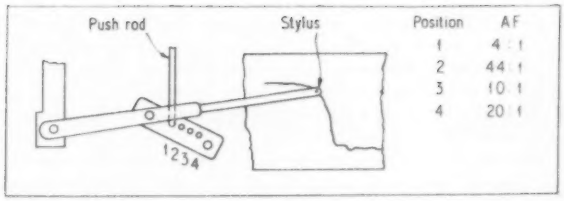
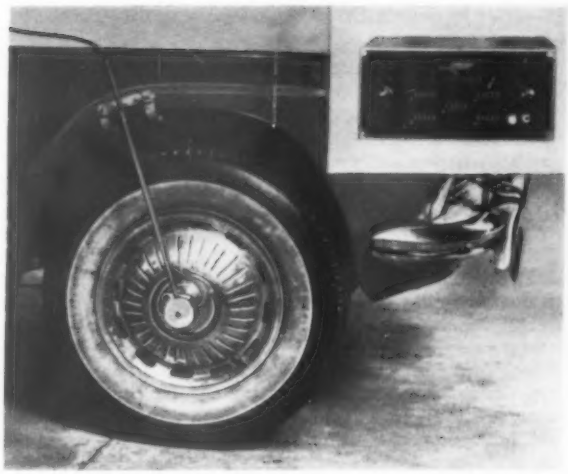


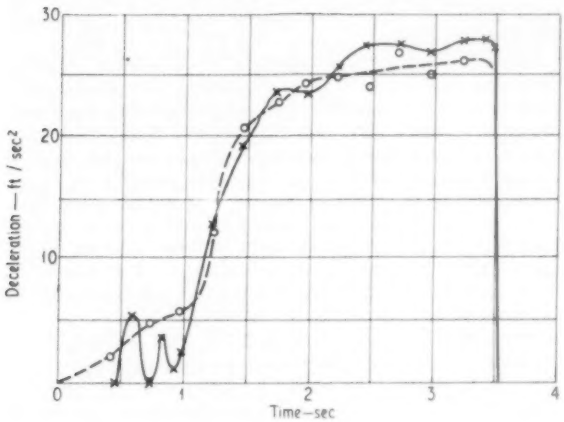
Fig. 7. Amplifying mechanism of the Askania recording decelerometer

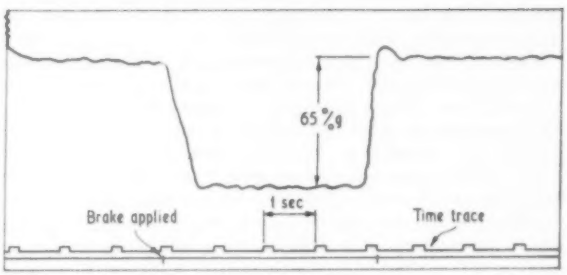
Fig. 10. Right: Impulse generator installation and, inset, the counter

Fig. 8. Below, right: Typical trace obtained from the Askania decelerometer

Fig. 9. Below: Comparison of results obtained with the Peiseler fifth wheel, dotted line, and the Askania recording decelerometer, full line







clockwork timing mechanism. Another pen, to indicate when the brake is applied and released, comes into operation when the fifth wheel is used. A typical trace is reproduced in Fig. 8. The electricity for operating the unit comes from 2V torch batteries.

Calibration can be carried out, at any time, by running the paper to give a datum line, rotating the case through 90 deg and running the paper again to obtain a second datum. The mass has then applied its full weight to the springs and the resulting deflection is equivalent to 1g, that is 32 ft/sec^2. It is claimed by the manufacturer that the unit, when calibrated in this manner, gives results accurate to within 5 per cent.

Curves of deceleration plotted against time, for a single brake application, obtained independently by the fifth wheel gear and the Askania instrument, are shown in Fig. 9. At this high rate of deceleration, the two curves are within 5 per cent of each other but, just after the brake has been applied, the mass has vibrated at its natural frequency; the trace at this point is typical of a damped oscillation.

The Peiseler slip counters, Fig. 10, take the form of impulse generators attached to the four wheels of the vehicle, the leads being connected to a counting box. Each lead is carried from the generator through a chromium plated tube secured to the vehicle wing by a rubber-bushed clamp. It has been found necessary to smear the tube with silicone grease to reduce friction. Another impulse generator incorporated in the fifth wheel measures distance. The impulse rate on each wheel can be two or four per revolution, and the maximum counting rate is 50 impulses/sec.

SINTERINGS ASSOCIATION

DURING the last few years, the use of sintered metals for the production of small components has increased greatly. Where the particular application lends itself to moulding in this manner, several advantages accrue. The more important of these are the absence of material waste and a marked reduction in machining costs, by comparison with other methods, because of the good surface finish and close dimensional control that are obtainable. Of considerable benefit in certain circumstances is the self-lubricating property that can be obtained, if required, by suitable impregnation during manufacture.

In order that users and prospective users of sintered components may derive the maximum benefit from the experience gained by specialist firms, The British Sinterings Association has recently been formed. Founder members include Bound Brook Bearings Ltd., The Manganese Bronze and Brass Co. Ltd., Metal and Plastics Components Ltd., The Morgan Crucible Co. Ltd., John Rigby and Sons Ltd., Sintered Metal Components (Chard) Ltd., and Sintered Products Ltd. The Secretaries of the association are Messrs Peat, Marwick, Mitchell and Co., Beaufort House, Newhall Street, Birmingham, 3.

To announce the formation of the association, a press reception was held in London on the 4th December 1958, at the Federation of British Industries, where numerous exhibits effectively illustrated the wide variety of items, both simple and complex, that can readily be produced by the sintering process. Among the automobile components on view were plain bearings of various kinds, pistons and valves for suspension dampers, and lock striker wedges.

Coolants for Chucking Automatics

The Development of Soluble Oils Suitable for High-Speed Operation with Sintered Carbide Tools

BECAUSE the chucking automatic is a more complex machine than the manually operated capstan or turret lathe it replaces, it is likely to have been designed for use with neat cutting oil as coolant. No exception can be taken to this since the operator is in far less intimate contact with the machine than with a capstan or turret lathe. Except whilst setting, his duties are reduced mainly to loading and unloading, to checking the dimensions and inspecting the surface finish of the work, and to replacing worn tools. Normally, he will be in charge of several machines, the number varying with the character of the work and the average duration of the work cycle.

Neat cutting oils will, in the majority of instances, be the most satisfactory choice when high speed steel tools predominate. Where adequate arrangements are available for the recovery of oil from the swarf, the use of neat oil is economical. However, if sintered carbide tooling is introduced, higher speeds are essential if the more expensive tools are to be exploited to the fullest advantage. These higher speeds produce more heat in the chip and the cutting oil is vaporized and burned, leading to the formation of fumes and smoke which may render working conditions objectionable and, in confined spaces, even intolerable.

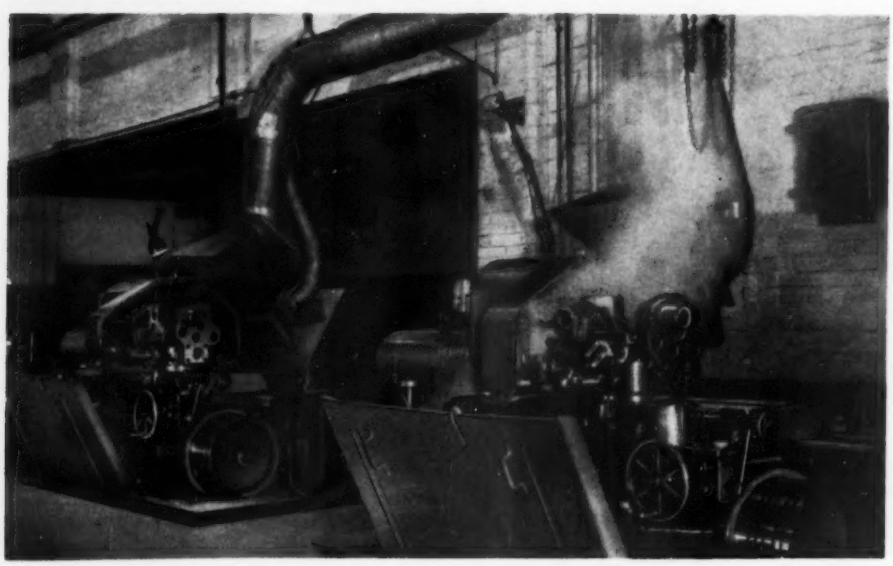
It may not be practicable to provide plant to recover oil from swarf for a relatively small number of automatic machines in a shop where the majority of other machines are using soluble oil emulsions. In these circumstances the consumption of neat cutting oil can be heavy and may be deemed economically excessive.

Basically, the chucking automatic is a capstan or turret lathe adapted to carry out the work cycle automatically, and normal practice on capstans and turrets is to use soluble oil emulsions as coolant. The emulsions, because of their water content, exercise a greater cooling effect than neat oils. Their low cost obviates any need for coolant recovery equipment, except provision for simple draining. It follows, therefore, that a solution of the problems of smoking, fuming, and a high rate of consumption is to change the coolant from neat oil to soluble oil emulsion. In this, however, certain pitfalls are likely to be encountered and some consideration must be given to these if satisfactory results are to be obtained.

First, as regards the machine itself. The chucking automatic is a much more complicated mechanism than a capstan lathe and, as referred to earlier, may well have been designed to work with neat oil coolant. There may be a risk of an emulsion entering enclosed gear systems, such as in the headstock and in the feed and speed gear boxes. Cams and trip mechanisms also may be washed by coolant. With many conventional soluble oils this could not be tolerated because corrosion and gummy deposits would cause rapid deterioration of the machine. The soluble oil used must be carefully selected, with a full knowledge of its properties.

Secondly, the question of tool life must be considered. As far as the sintered carbide tools are concerned there is not likely to be a serious problem. In most cases these tools will give adequate life with emulsions as coolant; a life, in fact, of the same order as that with neat oil. However, it will often be necessary to retain some high speed steel tooling in the set-up. High speed steel drills will usually run quite satisfactorily with soluble oil emulsions, but this will not always be so with H.S.S. form tools or reamers and it may be too expensive or too inconvenient to use sintered carbide in these applications.

In recent years special soluble oils have been developed containing additives similar to those used in heavy-duty neat cutting oils. These additives contain either sulphur or chlorine, combined with other elements in such a way that the active ingredient becomes available as an anti-weld



A comparative test of different coolants in the workshop under actual production conditions. Herbert chucking automatics machining drop stampings in En 8 steel at identical speeds and feeds. Machine on left operating with an extreme-pressure soluble oil; that on right with a high-grade neat cutting oil

agent under the conditions of high temperature and pressure generated at the tool cutting edge. The chemical combination, however, must be sufficiently close to prevent reaction of the sulphur or chlorine with machine components or the workpiece at normal temperatures. It is also desirable to embody fatty oils to reduce wear due to rubbing between the tool and either the swarf or the work. These soluble oils are mixed with water in the normal way but are most effective when used at lower than normal dilutions, say between 6 : 1 and 15 : 1. It is generally considered that the sulphurized, extreme-pressure, soluble oils are more satisfactory because of the possibility of hydrolysis of chlorinated additives in the presence of this water.

COMPARATIVE TEST DATA

Criterion: Number of holes drilled before failure
Drill: 0·3125 in diameter (H.S.S)
Speed: 1,200 rev/min
Feed: 0·010 in/rev
Depth: 0·50 in (blind hole)
Materials: B.S.328 tyre steel
Holes drilled at random
All steel from same batch

Drill No.	Fluid A	Fluid B	Fluid C
1	87	524	1,005
2	139	722	1,540
3	35	241	672
4	80	185	900
5	307	612	1,520
6	214	542	1,143
Average	144	471	1,130

Fluid A Conventional soluble oil
Dilution: 10 : 1

Fluid B Typical neat auto oil
(sulphurized fatty oil-mineral oil blend)

Fluid C Shell Dromus Oil 908
(extreme-pressure soluble oil)
Dilution: 10 : 1

Thus, there is available a coolant with the high quenching power of water—arising from the high specific heat of the water present and, also, because advantage is taken of the latent heat of vaporization of the water. (Oil vaporized would undergo a considerable change in composition and, unlike water, would not revert on cooling to its original state. Under the conditions of machining visualized, this accounts for the fuming of neat oils.) In addition to this high cooling power, something of the anti-wear properties of heavy-duty neat cutting oils is obtained.

Tables showing the comparison between (A) a conventional soluble oil, (B) a typical neat oil for chucking auto use, and (C) Shell Dromus Oil 908, an extreme-pressure soluble oil, are appended. These are based on drilling tests which, whilst not conclusive evidence for all operations, provide a reliable guide to the general comparative performance.

The best of these extreme-pressure soluble oils, when used in emulsions at, say, 10 : 1 dilution, will usually give tool life and finish comparable with those with neat oils on drilling and forming operations. With reaming operations the problem is a little more difficult. With materials such as En32, En16, En24 and plain carbon steels up to 0·4-0·5 carbon, good results will be achieved. It may be necessary to leave a little more metal to be removed from the hole, and to reduce the speed. The heavier chip will lead to freer sulphur release, which is inhibited with very light cuts by the high cooling power of the water. With the more refractory materials, for example En9 steel, it has in some instances been found satisfactory to substitute a final boring operation using a sintered carbide tool, for the reaming operation.

This type of coolant will meet the demands of the tooling engineer, but it is also necessary to satisfy the maintenance engineer. It has already been noted that the best of the extreme-pressure soluble oils contain a fatty additive in addition to the chemical extreme-pressure agent. If this additive is carefully chosen it can provide an excess of emulsifying agent over and above that required to stabilize the emulsion of the mineral oil contained in the original blend. If the coolant should enter gear systems, it will then mix with the gear oil and, provided its anti-corrosion powers are adequate, it will do no harm until the proportion of coolant to gear oil reaches a fairly high figure. There will, however, be alternate vaporization and condensation of water as the machine warms-up and cools-down. This condensate may fall on parts not flooded with lubricating oil and cause rust. Consequently, it is necessary to ensure that all gear systems are well ventilated. In some cases the machine builder will advise on this from previous experience. Indeed, in all cases the machine builder's advice should be sought, as he will often be able to suggest tried and tested modifications to assist in keeping coolant out of gear housings.

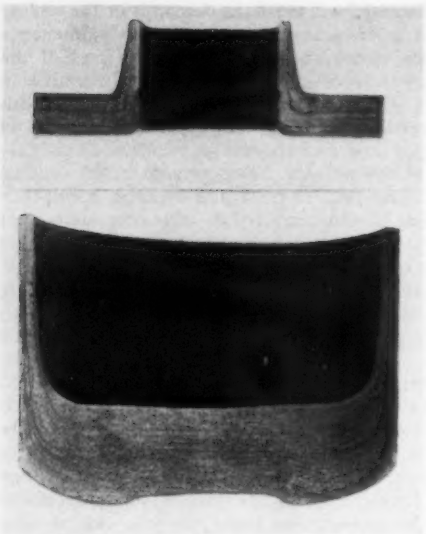
Experience, however, suggests that it is impracticable totally to exclude coolant from these systems. On the other hand, given satisfactory venting, no harm results from the presence of a small amount of coolant. Damage and deterioration can be prevented by regular inspection of the oil systems and, from this, arranging that they are drained and refilled at intervals short enough to prevent excessive concentrations of water. It is also necessary to ensure that slideways of the machine are regularly cleaned down, particular care being taken that chips are not left lying on a bed wetted with soluble oil emulsion over a week-end or a holiday. The use of soluble oil emulsion on chucking automatics demands care and planned maintenance. If this is provided, and the soluble oils are carefully selected, there is no reason why extra wear or more rapid depreciation should occur.

To summarize: the chucking automatic gives excellent service under normal conditions with neat cutting oils and provided an adequate recovery service exists this is also economical. If because of very high rates of metal removal there is excessive smoking with neat oil, then it is practicable to change the coolant to soluble oil emulsion. Should this be done, the soluble oil must be carefully selected, minor modifications to the tooling and the machine may be called for, and careful attention must be given to machine maintenance. The overall costs are not likely to be substantially altered either way, but production can be up-rated and shop conditions can be vastly improved.

These notes were prepared from the report of a study made by V. G. J. Haden, B.Sc. of the Lubricants Department of Shell-Mex and B.P. Ltd. It must be emphasized that they refer specifically to single-spindle chucking automatics. Multi-spindle machines are often extremely vulnerable to leakage of coolant to lubricant and *vice versa* and great care is essential in the application of soluble oil coolants.

Semi-Trailer Coupling

AN interesting feature of the Brockhouse Mk IV interchangeable semi-trailer coupling is the use of a Clayton Dewandre Hydrovac suspended vacuum servo unit for trailer brake operation. This was mentioned in an article, entitled "Trailer Progress", in the January 1959 issue of *Automobile Engineer*, but in this article it was stated that the reduction obtained between initiation of the braking action by the driver and the actual application of the trailer brakes is said to be from 6 sec to 1 sec. These figures, of course, should have been 0·6 and 0·1 sec for the time reduction.



The Cold Extrusion Process

Equipment Now Being Installed by Forgings and Presswork Ltd. for the Supply of Cold Extruded Components to Industry

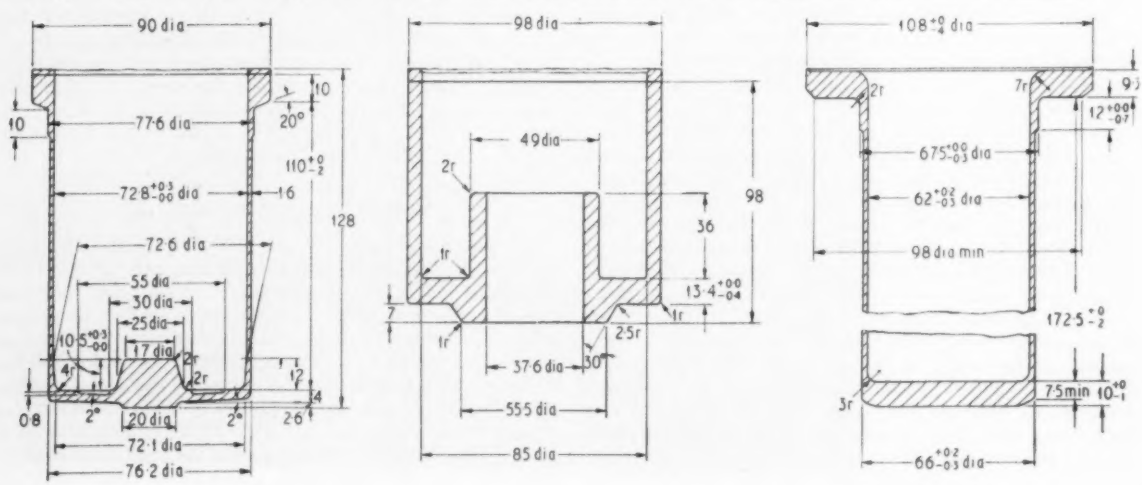
SOFT-METAL containers of the collapsible tube type have been manufactured by extrusion for nearly a century. Only in recent years, however, have the necessary extrusion techniques been developed for the cold working of relatively high strength materials such as aluminium alloys, copper, and steel. Components of suitable type and configuration can be cold extruded with substantial economy as compared with production by traditional methods of hot forming and machining or machining from bar stock. The metal is worked by one or both of two methods; forward extrusion or backward extrusion. In the first, the metal is forced through a die orifice in the direction of the punch movement. In the second method the metal flows backwards between the punch and the die in a direction opposite to that of the punch movement. Whichever the method employed, all forces are compressive and, consequently, there is no tendency for the metal to rupture. Under these circumstances, the amount of deformation possible is much greater than is practical where the metal is stressed in tension. In deep-drawing operations, for example, the wall strength of the drawn cup limits the amount of permissible reduction, since the deforming load is carried as a tensile stress in the wall. Only the work-hardening propensities of the material being worked and the load-sustaining capabilities of the tools limit the permissible deformation when using the cold extrusion process.

Continual increases in the cost of raw materials compel production engineers to seek means of raising the proportion of the stock material that is usefully embodied in the component. It is somewhat of an anomaly to use expensive tools and labour to machine any substantial proportion of relatively high-cost material into low-value scrap, if it can possibly be avoided. Cold extrusion can in favourable cases offer up to 95 per cent utilization of stock material.

During cold extrusion operations, the severe cold working raises the hardness and strength properties of the material. Although this inherent characteristic is an embarrassment where further working is necessary in a specific component, in the majority of instances it constitutes an outstanding advantage. Low-carbon steels, as a result of cold working during extrusion, acquire mechanical properties approximating to heat-treated carbon steels or low-alloy steels. This aspect, doubtless, was a prime reason for the intensive

Heading illustration, above, shows etched sections of cold extruded components, revealing characteristic smooth grain flow of the material

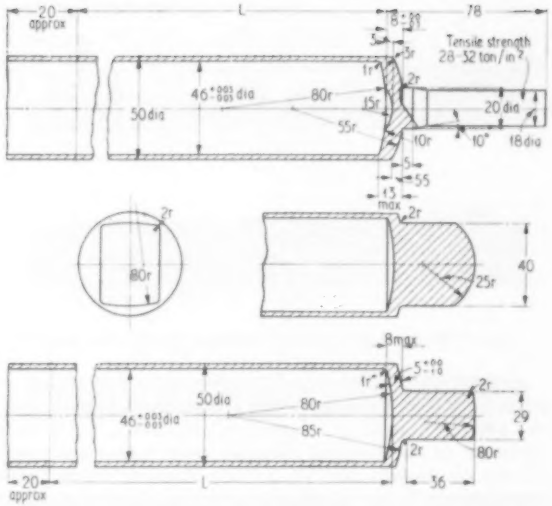
Below: typical thin-walled extrusions with heavy bases, flanges, and bosses, as received from the press. All dimensions in millimetres



development and exploitation of the process in Germany during World War II.

Of course, complicated machine parts cannot be made by simple extrusion alone. Other steps of cold working, coupled with surface and heat treatments, are incorporated as may be required. Surface treatment, in the form of phosphating and lubrication, is vitally necessary in order to reduce the high friction between metal and tools. Stress-relieving and other anneals are needed to return the work-hardened metal to its ductile condition so that further working may be carried out.

Unfortunately, the development of cold extrusion techniques has not been so vigorously pursued in Britain as in Germany and the U.S.A. Although several press manufacturers are prepared to supply tooling to make specific parts with new presses, there has hitherto been no plant in operation designed to produce a general range of components for engineering applications. Manufacturers have been unable to take advantage of extrusion methods unless prepared to install and operate a plant themselves, and this has discouraged many from considering the use of extruded parts. Forgings and Presswork Ltd., Birch Road, Witton, Birmingham, 6—a Birfield company—is now installing a selection of presses capable of producing a wide range of components for general engineering purposes and thus the advantages of the process will be available to all interested manufacturers. In order to ensure that development times are cut to a minimum, and to provide a comprehensive and reliable service, Forgings and Presswork Ltd. has secured the sole licence for Great Britain from Kabel- und Metallwerke Neumeyer A.G. This concern was the originator of modern cold extrusion techniques, and operates in Germany as a general supplier of extrusions in ferrous and non-ferrous metals. The extensive experience, acquired over many years, will be applied here, and production problems will thereby be considerably reduced.

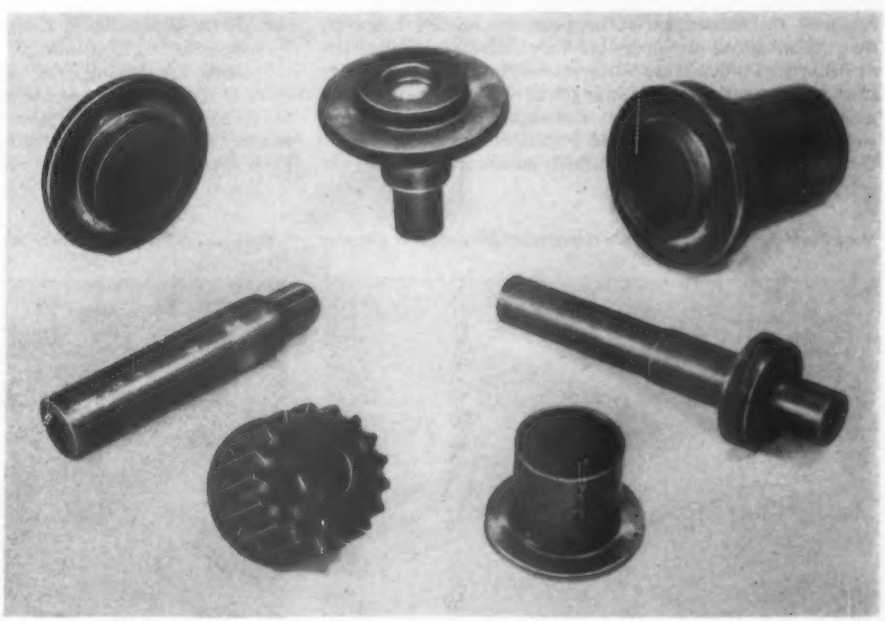


Extruded shock-absorber cylinders with suspension stems or eyes. The internal diameter is specified as free from tooling marks or grooving. Length (L) may be in four sizes ranging from 200 to 295 mm

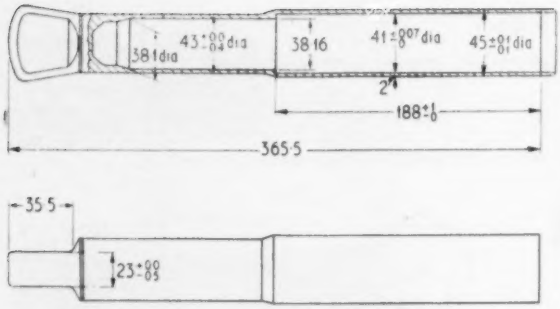
Shapes suitable for extrusion

A selection of extruded parts that are in regular production is illustrated. In order to facilitate smooth metal flow, the part should be as near symmetrical as is possible, but this does not imply that only parts of circular section can be manufactured. In general, most regular polygonal sections can be produced, with size of section limited only by press capacity. Wall thicknesses can be reduced to as little as 0·02 in and changes of section throughout the length are possible. Forging draft and other extraction tapers are not required and would, in fact, be a positive hindrance to flow. The designer, therefore, is freed from the necessity of providing these features, which must often be removed by a subsequent machining operation.

Since the part has to be withdrawn from a rigid die, it is obvious that details resulting in undercuts cannot be incorporated in a design and must be produced subsequently by machining. Much has been written about the production of extruded gear teeth. Although certain teeth and splines have been, and are being, extruded under production conditions to satisfactory tolerances, it must be emphasized that an individual appraisal of each intended application



Typical cold extruded components. On the lower left is an extrusion from which three chain sprockets are subsequently parted off



Two-diameter lower spring tube for motor-cycle telescopic front fork

must be made before any opinion could be expressed about the practicability of its production. Normally, the working tolerance of an extruded diameter is such that gear teeth, splines or threads can be directly formed without prior machining. When a cylindrical or cup-like extrusion is required, it should be noted that the thickness of the base is independent of the wall thickness. Thin-walled cups with heavy bases are readily producible. In addition, bosses, depressions, or other details can be incorporated and flanges can be included as a feature integral with the cup wall.

As a consequence of working at room temperature, no allowance for shrinkage or scaling needs to be made. This enables working tolerances to be held far more closely than with most other forms of working. The allowable tolerance, of course, determines the life of the extrusion tooling. Tolerances which are tighter than necessary should, as with other manufacturing methods, be avoided. It is often possible to hold certain dimensions to as little as 0·0015 in total tolerance if necessary, for example, in the bore of a hydraulic work cylinder, but this may necessitate an extra sizing operation which increases production cost. Hollow parts are virtually free from bending, but slender solid parts tend to show a slight deviation from truth.

Properties of extruded steel components

When steel or other metal is cold worked, the resistance to deformation increases progressively. Eventually, if working is to be continued, the induced hardness and strength must be removed by annealing. It happens frequently, however, that the enhanced properties are very desirable. One of the advantages of the cold extrusion process is that lower-quality steels can be worked to the strength of more expensive, heat-treated steels. It is possible, for example, to use low-carbon steel worked to a strength of 40-50 ton/in² instead of a heat-treated, medium-carbon steel. Such enhanced properties are lost by heating above the re-crystallization temperature and parts required to operate at elevated temperatures must be designed accordingly. A stress-relieving heat treatment may be employed to increase ductility without marked loss of strength.

During the last war a special steel was developed in Germany for the extrusion process. It is resistant to strain ageing and is aluminium killed. Use of this special steel, which is now available in Britain, obviates the risk of strain-age embrittlement and thus removes the need for stress relieving, providing that ductility is of secondary importance. Owing to the risk of soft spots, such steel should not be used for carburized work. In such cases heating for carburizing will remove all effects of cold working, and normal carburizing steels should be used.

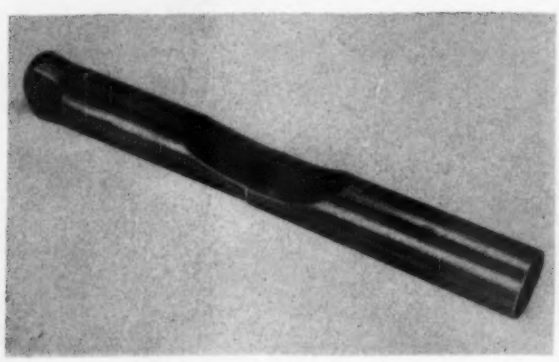
It is often found that a part redesigned for extrusion is stronger than the original, especially under fatigue conditions. A number of reasons lie behind the improvement. The extremely high pressures and smooth phosphate lubricant produce a finish which is comparable with a ground surface and has been measured at 1-4 μ. It is, of course, well established that a smooth surface is conducive to long fatigue life. In addition there is evidence that the stress distribution in an extruded skin is favourable to enhanced life.

Since the part is finished closely to its final form, there is little subsequent machining to cut through lines of grain flow and expose possible stress raisers. The pattern of flow lines in an extrusion follows the external contour closely and is superior even to that of a forging, where generous machining allowances are usual and really deep piercing is impossible. Pressure tightness of vessels designed for holding compressed gases can be improved by buckling the grain in the base of the vessel, thus closing the micropores which sometimes occur in the centre of billets.

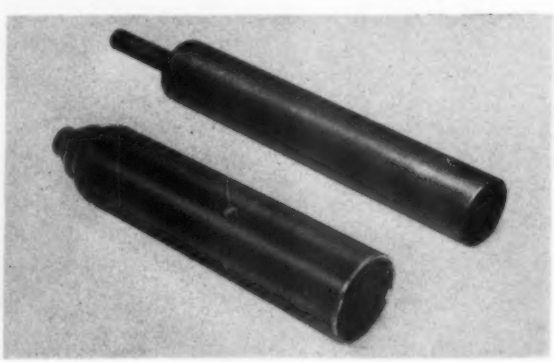
The surface of an extruded part is coated with a thin, shiny and hard phosphate layer which has several desirable properties and some disadvantages. During storage, corrosion is inhibited, especially if the part is lightly oiled. Paints, enamels, and rubber adhere well, but both electrolytic and hot-dipped plating is prevented by the coating, which has to be removed in such cases. Removal is readily accomplished by pickling. Welding invariably necessitates removal, and although an acid flux often enables soldering to be carried out, removal is commonly more expedient. Local removal suffices for both welding and soldering and may be effected by wire-brushing or grinding.

Heating for welding will change the physical characteristics of the affected zone and allowance for the change must be made if the part in question is to be employed at the enhanced level of strength brought about by cold extrusion. Heat treatment is usually confined to stress relieving or

Motor-cycle fork spring tube, part sectioned to show stepped diameter



Hydraulic cylinders. The lower one has internally two guide splines

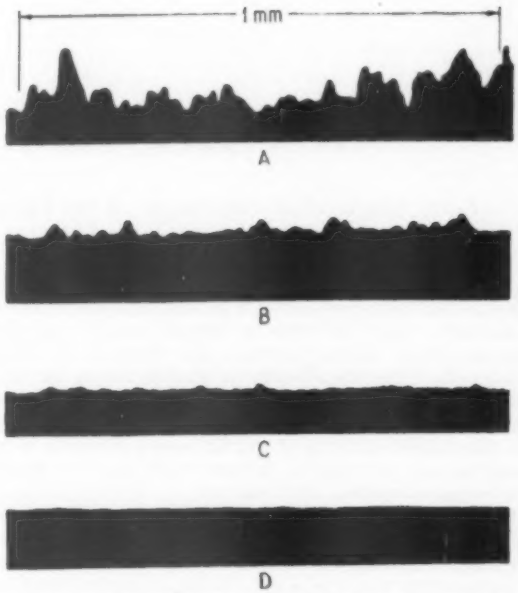


carburizing and the phosphate has no effect on either of these operations. The unusually good phosphated finish is employed to advantage in hydraulic and pneumatic cylinders where the smooth layer reduces friction and wear, particularly during the initial stage of working.

Steels suitable for extrusion

The method of applying only compressive stresses to the material being deformed, and thereby obviating rupturing tendencies, would appear to allow a wide latitude in choice of material. In practice, however, the ability of tool steels to withstand extrusion pressure narrows the range of suitable alloys. Any alloy which in its softest state possesses a low yield point and retains its plasticity over a reasonable range of working may economically be extruded. The pressure required for a given reduction in section increases steeply with carbon content and also rises with increasing alloy content. Hence, at the present state of development, heavy reductions are possible only on low-carbon and low-alloy steels.

For any but very simple extrusions, therefore, production is at present limited to steels of carbon content below 0·18 per cent and of low alloy content. The limitation is of importance where it is desired subsequently to induction harden or flame harden surface layers. In such instances a medium carbon steel is essential. The alternative, of carburizing before such a hardening treatment, is not likely to prove of economic interest. When properties of a heat-treated steel are required throughout a section, it is often possible to provide the desired strength by employing the improvement brought about in low carbon steel by extrusion.



Comparative profiles of surfaces produced by different methods. Recorded on Leitz apparatus. Magnification of roughness, ×1,000. A finish turning, 10-15μ; B fine grinding, 1-10μ; C cold extrusion, 0·3-3·5μ; D medium polish, 0·16-0·63μ

Economics of cold extrusion

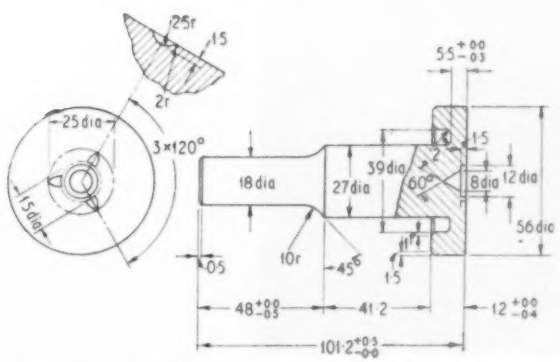
The cold extrusion process employs equipment which tends to be more expensive for its capacity than comparable equipment used for similar but less arduous work. For example, extrusion presses of the mechanical type must be robust and must develop their rated capacities high up the stroke. Alternatively, hydraulic presses may be employed, but in either case the machines are relatively expensive. Since the work is carried out at room temperature, the energy required to bring about a certain deformation is high and the extent of deformation possible between annealing is limited.

The production of a complicated part may require several different press operations with interstage annealing and surface treatments. The cost of this large amount of work must be offset by the savings effected by using the intrinsic advantages of the extrusion method. Economic extrusion is usually attained only under fairly large-scale production conditions. Experience in Britain does not yet allow the lower figure of economic batch size to be determined, but it is thought that a figure of 5,000 will represent the limit. However, as in other aspects of extrusion, individual examination of each case is desirable before a decision is reached.

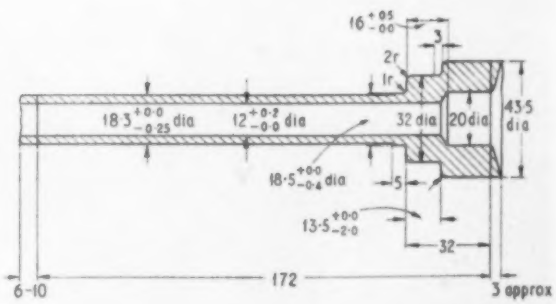
Extrusion methods may be made economic by utilizing the savings offered in the inherent dimensional accuracy attainable, and in the shapes that may be formed. These factors give rise to reduction in the amount of material consumed and reduction or elimination of machining. It usually follows that hollow parts offer higher savings in material than solid parts and there is a tendency for hollow or pierced components to show the greatest advantage.

Other contributory factors include the practical utilization of low-carbon steel and cold working to attain the properties of a heat-treated steel. This results in savings in the cost of the steel and in the elimination of heat treatment. The extrusion process imparts an excellent surface finish to the work and the need for any subsequent finishing operation is either reduced or obviated. This fine finish also improves the fatigue strength of the part, which is further enhanced by the uninterrupted grain flow which is an inherent feature.

Solid coupling flange with location depressions



High-duty tubular coupling member



ROTARY MELTING FURNACES

Some Mechanical Advantages of the Tilting Type of these Economical Production Units

ARISING from a similarity in general appearance as well as in name, some confusion occasionally occurs regarding standard rotary melting furnaces and units of the tilting rotary type. Since the Monometer Manufacturing Co. Ltd., Savoy House, Strand, London, W.C.2, long established as makers of standard rotary furnaces, has recently acquired the manufacturing rights of the Stein and Atkinson tilting rotary furnace, the features of both types can be examined and compared without invidiousness.

Both types are of large capacity and are specifically designed for bulk melting. In respect of construction, operation, and automatic control they are similar. It is probably of advantage to regard them rather as molten metal production machines than as the simple type of plant traditionally termed a melting furnace.

Standard type

In essentials, a standard rotary furnace is a cylindrical steel shell lined with refractory, and is fired by a burner at one end. Supported in an axially horizontal position on rollers, it is rotated during the melting period. The molten metal is tapped from a spout which may be situated in the middle of the furnace body or, when required, mounted on the conical end of the body. The rotation of the furnace during mixing and melting is one of the reasons for its extremely low fuel-consumption rate. Not only is the metal brought down by flame radiation over and through the charge but also by contact with the heated refractory lining of the furnace as it revolves.

The rotary motion also serves to prolong the life of the lining, since during rotation the lining is cooled by contact with the charge. Useful heat is absorbed by the charge, so that overheating of the lining does not occur. The open-ended construction of the furnace makes it easy to arrange for the products of combustion to be discharged into an efficient form of recuperator for preheating the air supply. A recuperator is particularly necessary when melting irons or steels. Rotation of the furnace is effected by a suitable mechanical drive.

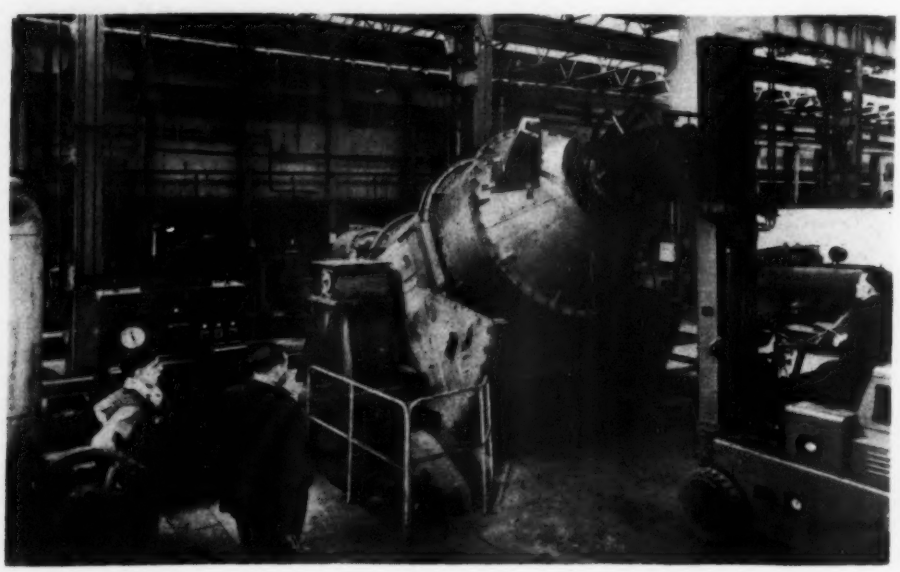
Tilting type

The tilting rotary furnace also consists of a cylindrical shell, rotating on rollers during the progress of a melt. It can, likewise, readily be arranged for the products of combustion to be passed into a recuperator. In this case, however, it is mounted over a pit and the cylindrical shell, with the rollers and rotating gear, is carried in a cradle furnished with a quadrant gear. This cradle is supported at each side on trunnions in the manner shown in the cross-sectional view.

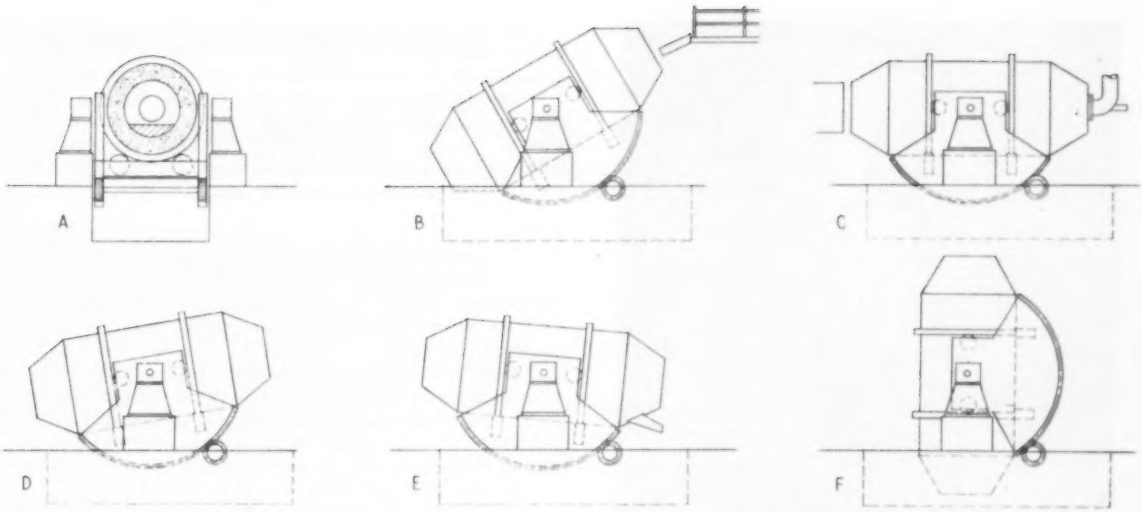
PERFORMANCE DATA

2-ton rotary furnace on C.T.F. 200 fuel or 600-sec fuel oil

Metal	Pouring temperature deg C	Fuel consumption gal/ton	Melting time hr
Malleable iron	1,500	30	2
High-duty iron alloy	1,450	25	1½
Copper	1,250	18	1½
Gunmetal	1,140	15	1½
Aluminium alloy	675	8	1



Charging an elevated tilting rotary furnace by means of a mechanical truck



Diagrams showing tilting rotary furnace in section and in various operational positions

A *transverse section;* **B** *charging;* **C** *melting;* **D** *slagging;* **E** *pouring;* **F** *re-lining*

The construction allows the furnace to be tilted axially to any convenient angle, as indicated in the diagrams.

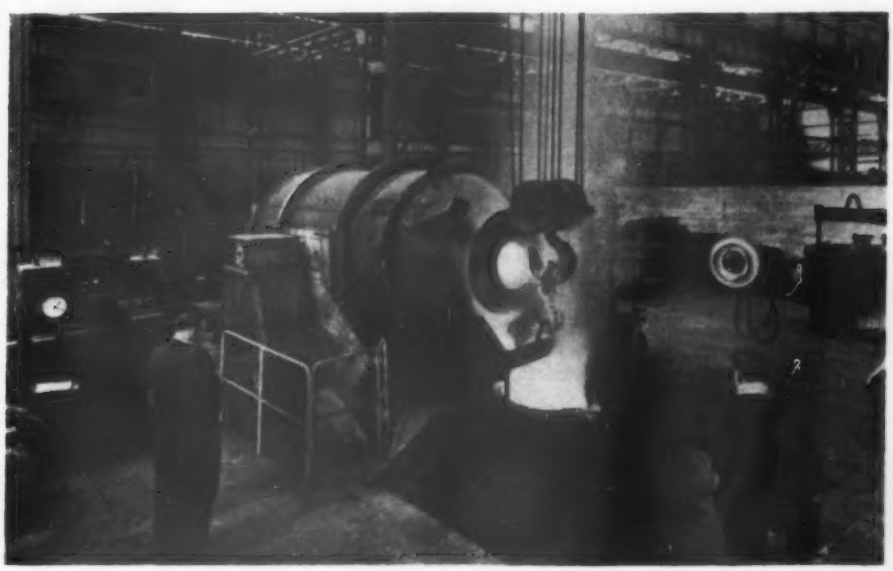
Referring to the diagrams; the position for charging, either from an overhead platform, a hopper and chute, or a mechanical charging truck, is shown at B. At C the furnace is in position for melting, with the fuel burner on the right and the duct carrying the combustion products to the recuperator on the left. Slagging and pouring elevations are shown at D and E respectively. If required, the pouring spout can be fitted at the other end of the furnace. Only a small movement of the spout is necessary from the start to the finish of the pour.

When re-lining of the furnace becomes necessary, the body is tilted to the vertical position, as at F. Re-lining can then be effected, either by bricking or ramming, without the need to take the body off its mounting. Thus, down time and expense of this periodical maintenance operation are reduced.

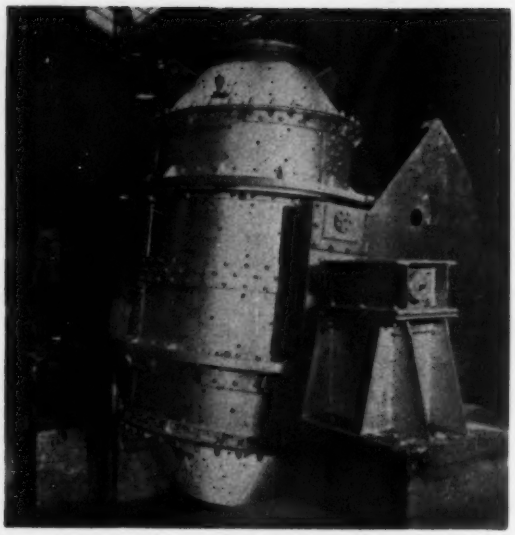
Advantages of rotary furnaces

The specific advantages of the tilting type of furnace are purely mechanical and operational. They may be summarized as (1) ease of loading, (2) easy disposal of slag, and (3) the facility of re-lining without the necessity of dismantling and removing the body. As regards melting efficiency, there is no difference between the two types.

Rotary furnaces are used extensively for the production of malleable irons and of high-duty iron alloys, as higher temperatures than are possible in cupola melting can be attained. Furnaces for such purposes are equipped with fully automatic air : fuel ratio controllers. Due to the atmospheric control exercised by these controllers, carbon and silicon losses are very low. Furthermore, consistent metal analysis can be obtained from successive batches produced. This requirement, incidentally, is likely to be a limiting factor when cupola melting is employed.



The pouring operation. On the right is the fuel burner, swung out of position on its radial-arm support



Tilting rotary furnace elevated to a near-vertical position for re-lining and routine maintenance

They are used for the large-scale melting and refining of copper and, at a lower temperature, for the bulk melting of metals such as aluminium-silicon alloys. In melting over 100 tons of aluminium scrap and foundry returns, with a fuel oil consumption of 8 gal/ton, the metal losses are as low as 1·98 per cent. They are very suitable for the refining of swarf and the reduction of lead residues, battery plates, and drosses; yielding a high return of metal.

Fuels

Fuel costs, by reason of the principle employed, are claimed to be lower than those for any other type of furnace of comparable output. Melting times and fuel-consumption rates for various metals in a 2-ton rotary furnace are given in the appended table.

The rotary furnace can be operated satisfactorily on a variety of liquid and gaseous fuels. That most widely used is fuel oil of any grade, with calorific values up to 19,000 B.t.u/lb. Creosote-pitch mixture, C.T.F.200, of about 16,500 B.t.u/lb, is also an excellent fuel that is much used for melting irons and steels.

Any conveniently available gaseous fuel will give excellent results; town gas at 450-500 B.t.u/ft^3, producer gas at about 120 B.t.u/ft^3, or natural gas at 1,000 B.t.u/ft^3 or higher. The consumption of gas per ton of charge will correspond fairly closely with that for the liquids fuels, reckoned in therms.

Adhesive Tapes

FOR the repair of drawings and documents, a new transparent adhesive tape has been introduced by the Industrial Sellotape Division of Gordon and Gotch Ltd. The new material is known as Sellotape Permanent Repair tape and is claimed not to stretch, wrinkle or go yellow with age. It can be written on in Indian or other ink, or in pencil of up to 4H grade, and will also accept printing. There is no oozing from the edges of the tape and tests have shown it to be satisfactory for drawings which have to be photo-printed. The repair tape is made in three widths up to 1 in and is supplied in rolls having a length of 30 yards and wound on a 1 in diameter core.

A second new Sellotape product is the Double-sided Adhesive Filmic tape. It has a number of factory uses including the temporary joining of components or the holding of templates. This tape is available in a wide range of widths. It is protected on one face by an embossed plastics film, which need not be torn off until the outer adhesive surface is actually required. The address of the manufacturers is 75 to 79 Farringdon Street, London, E.C.4.

Russian Translation

AMONG the world's most authoritative journals on welding is the Russian monthly *Avtomaticheskaya Svarka*, or *Automatic Welding*, which is to be translated regularly into English by the British Welding Research Association. The first issue to be translated is that for January, 1959, which is expected to arrive in this country in March and to be distributed in its completely translated form in late April or early May.

According to the Association, the title of the journal, though unique, is not absolutely descriptive, because occasional mention is made of manual techniques, though these are not emphasized. Welding methods and equipment are dealt with, as are metallurgy, the strength of welded work generally, and fatigue testing. The journal has been in existence for some twelve years and is the organ of the Arc Welding Institute of the Order of the Red Banner of Labour, at Kiev; the Institute is a section of the Ukrainian S.S.R. Academy of Sciences.

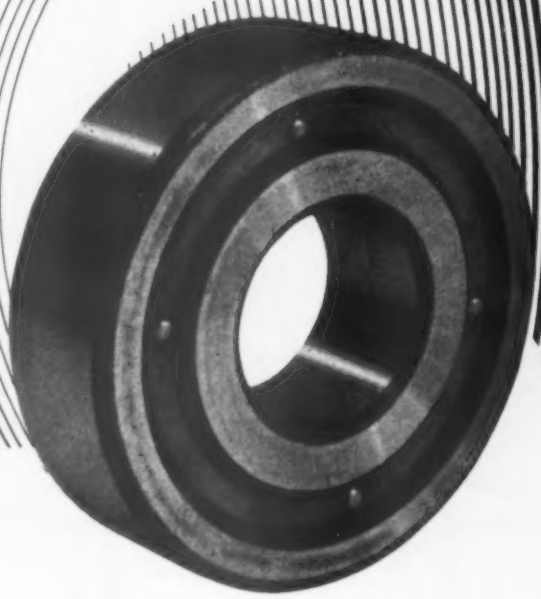
To give potential subscribers an idea of the scope of *Avtomaticheskaya Svarka*, the Association has arranged for the August, 1958 issue to be translated as a specimen for loan purposes. It contains an editorial summary of the U.S.S.R. seven-year plan, 1958 to 1965, as it applies to welding, and fifteen contributed articles, three of which deal with electro-slag welding. The subscription price for the translations will be £10 10s for the twelve issues for 1959. Subscription applications, or requests for the loan of the specimen issue, should be made to the British Welding Research Association, 29 Park Crescent, London, W.1.

Plastics Coatings

A NEW plant has recently been installed by Darlaston Galvanized Holloware Co. Ltd., Progress Works, Holyhead Road, Wednesbury, Staffs., for the purpose of bonding polythene and other plastics materials to ferrous or non-ferrous metal components. Known as the Plasinter process, the technique developed by the company is claimed to overcome the peeling difficulty sometimes encountered with this type of coating in the past. Among the items that can be treated are wire work, tubular steel structures, sheet metals and castings.

In addition to polythene, the plastics that can be used for the coatings include nylon, p.v.c., p.t.f.e. and p.t.f.c.e. These coatings provide protection from corrosion by atmospheric or chemical action, are non-toxic and will withstand sterilization in boiling water. They provide good electrical insulation and, in many instances, add to the strength of the component or assembly. The manufacturers state that the Plasinter process overcomes to a considerable extent the inherent disadvantages of an all-polythene article the most notable of which are porosity and the induction of static electricity. The coatings are available in a variety of colours, and the cost is said to compare favourably with that of the finishes that currently are widely used in industry.

WHAT A LIFE!



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years of it, is the startling record of this Hoffmann Ball Bearing on a Royce crane. And after this marathon run, wear is imperceptible on the moving parts and only very slight damage to tracks, due to the ingress of foreign matter.

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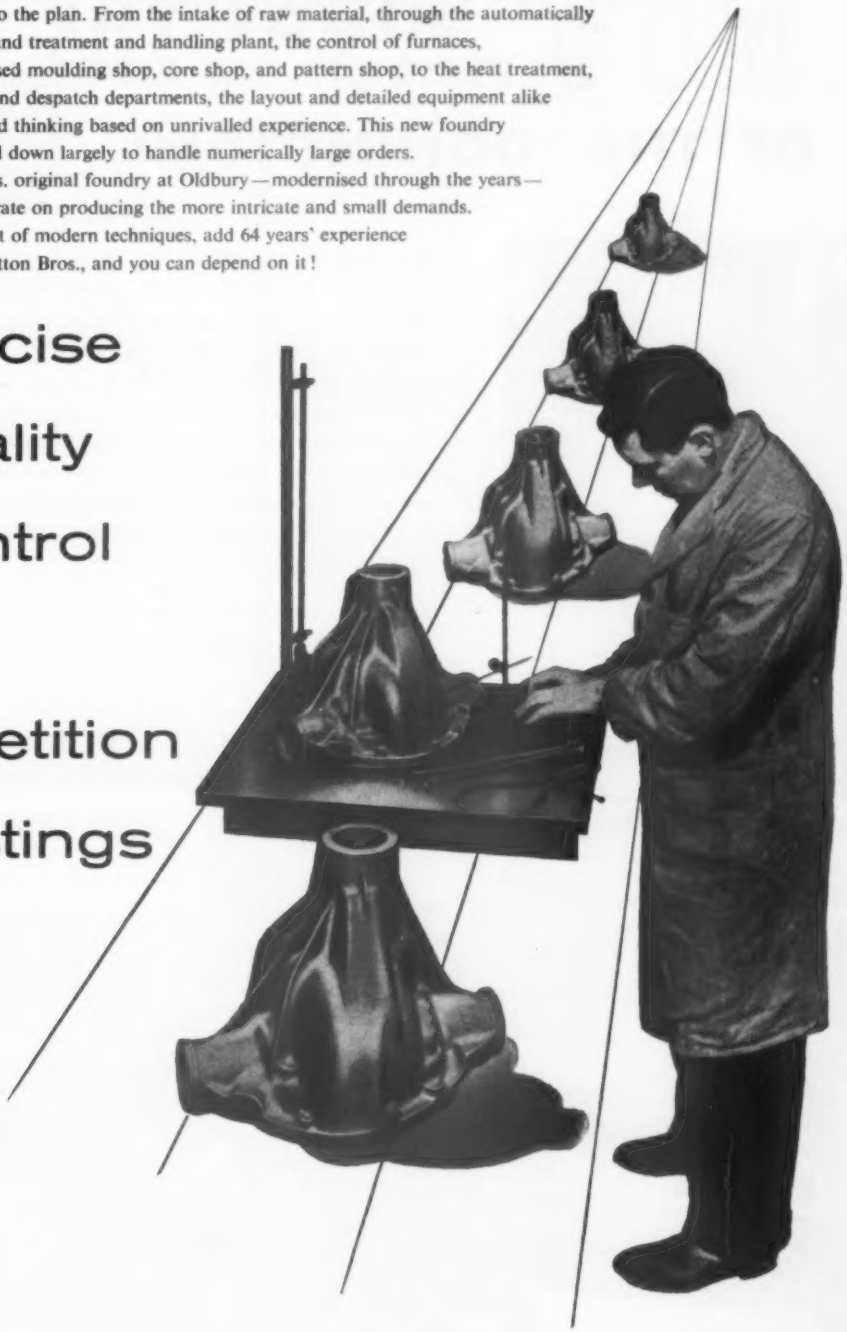

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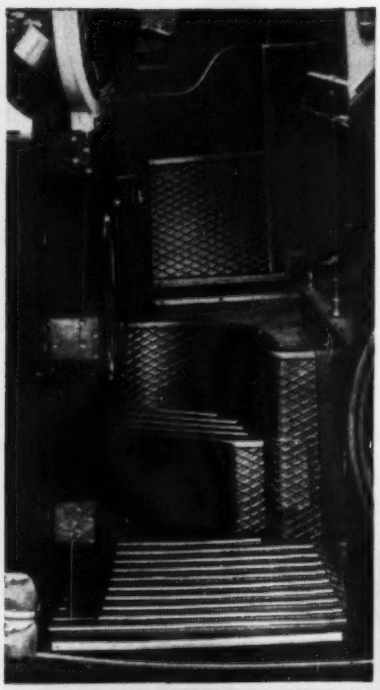

The steps of attractive, non-slip chequer plate which greet passengers boarding the Duple 'Donington' coach give the most favourable of first impressions. But smartness is only one role of light-weight 'MG5' chequer plate in modern coaches. This James Booth diamond-patterned light alloy plate stands up to the roughest treatment, day in and day out—the kicking, scraping and treading of many feet and the grinding of mud and gravel underfoot. Then just a quick wash down brings it up clean and shining new. 'MG5' makes the ideal chequer plate for places subjected to the heaviest wear—stairs, decking, kickplates, wheel-arch covers and other furnishings. One-third of the weight of steel yet comparable in strength, 'MG5' will not rust, is resistant to corrosion and never needs to be painted.

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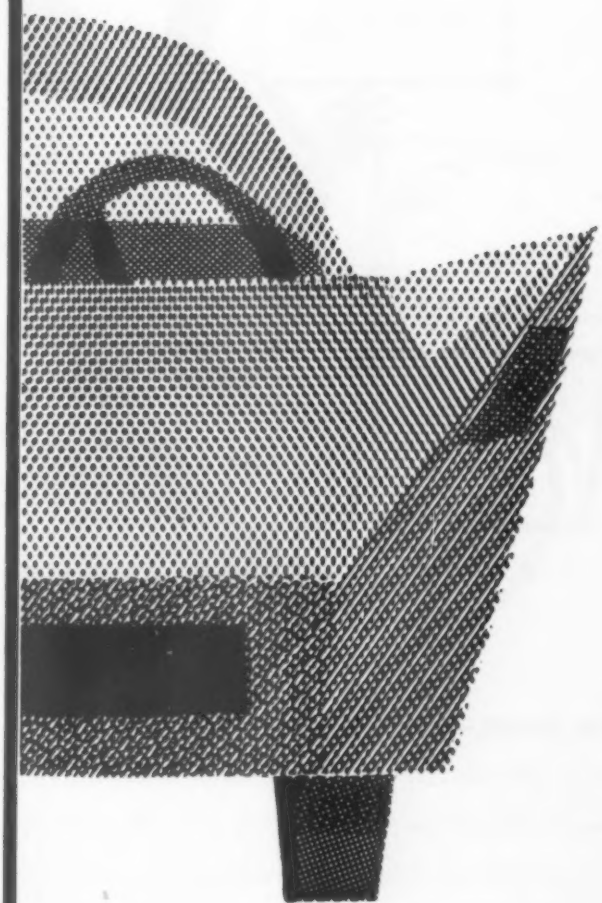

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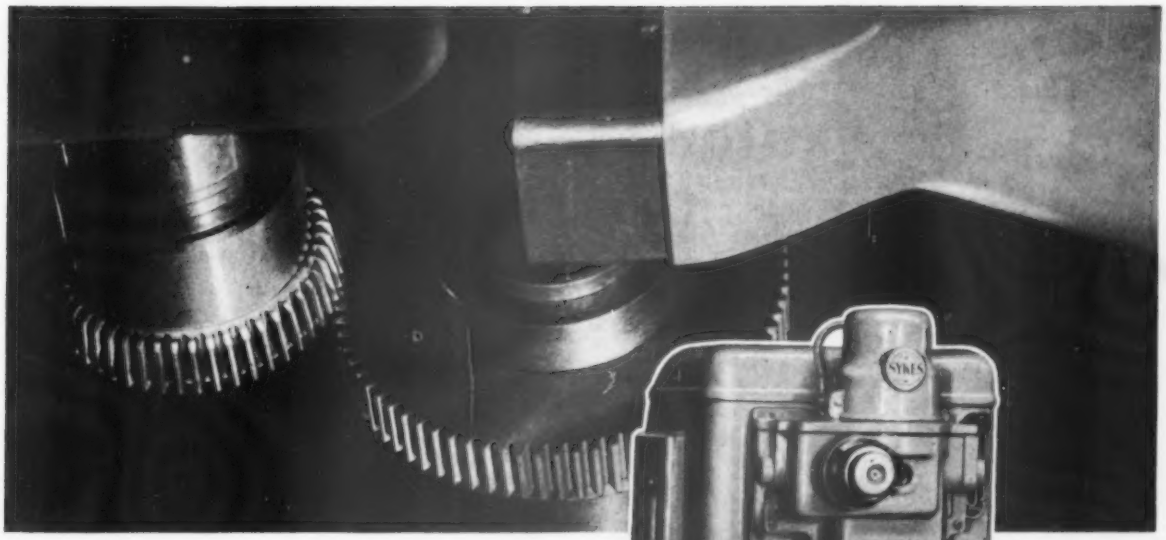

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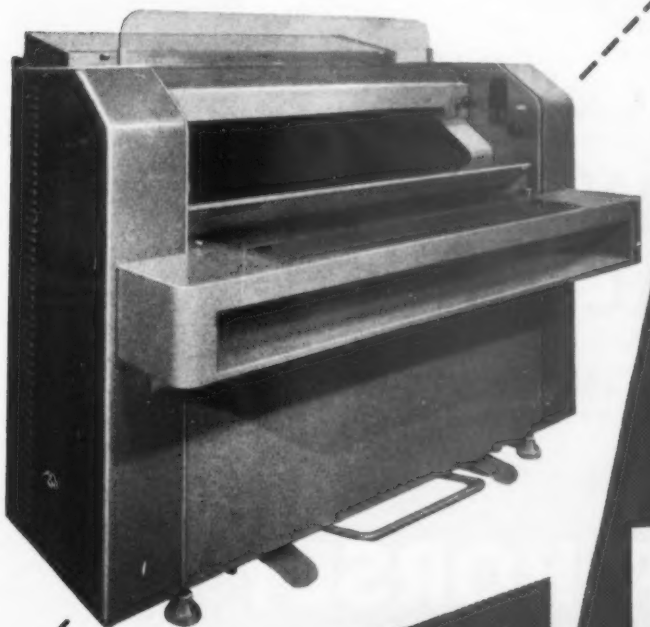

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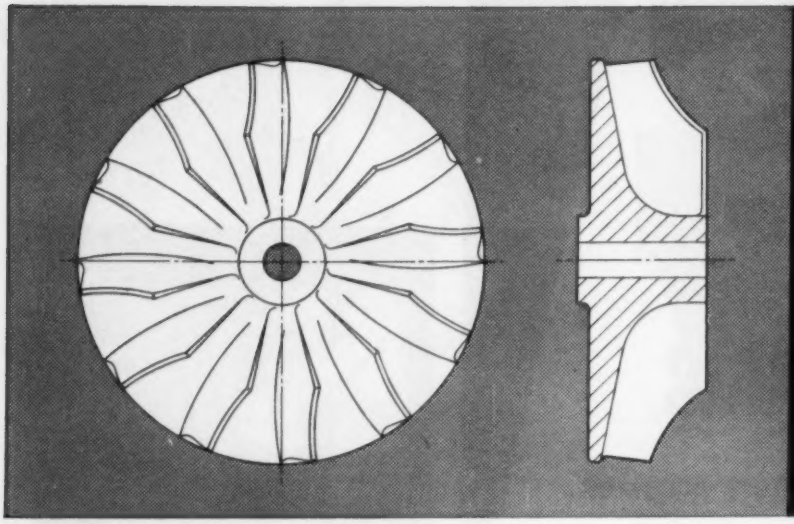

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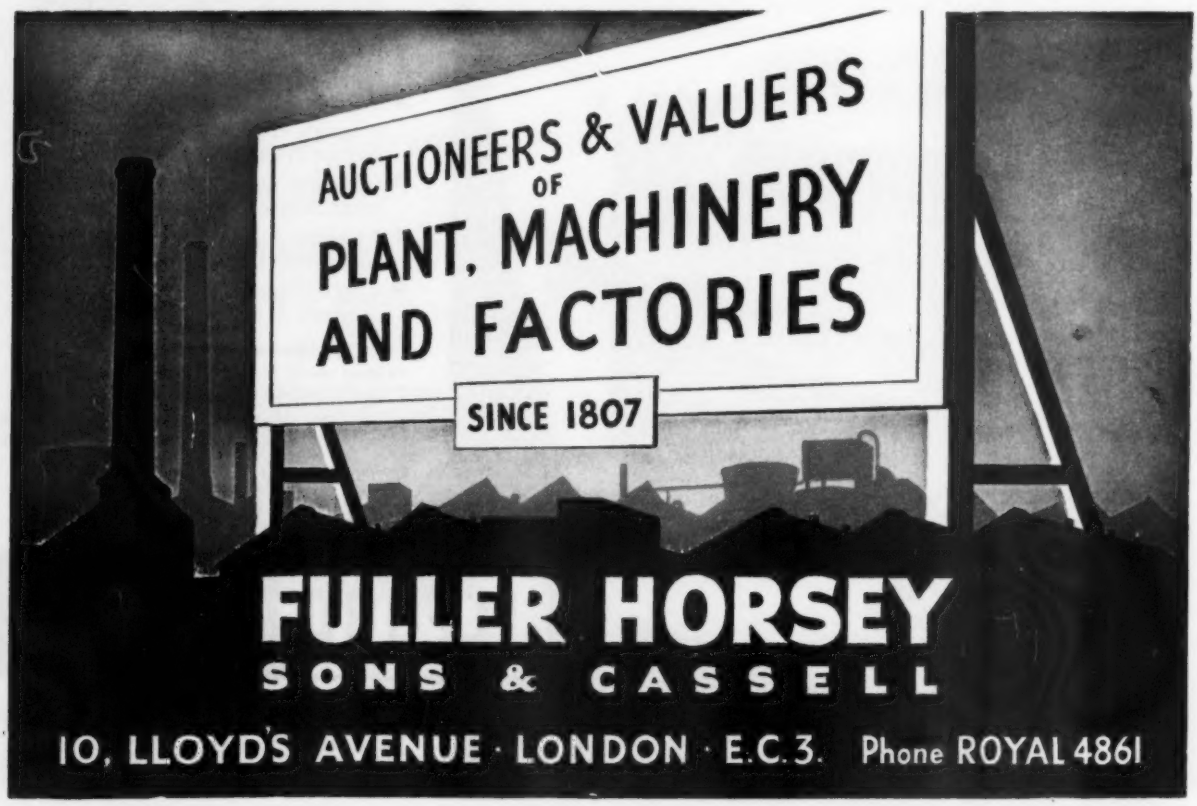

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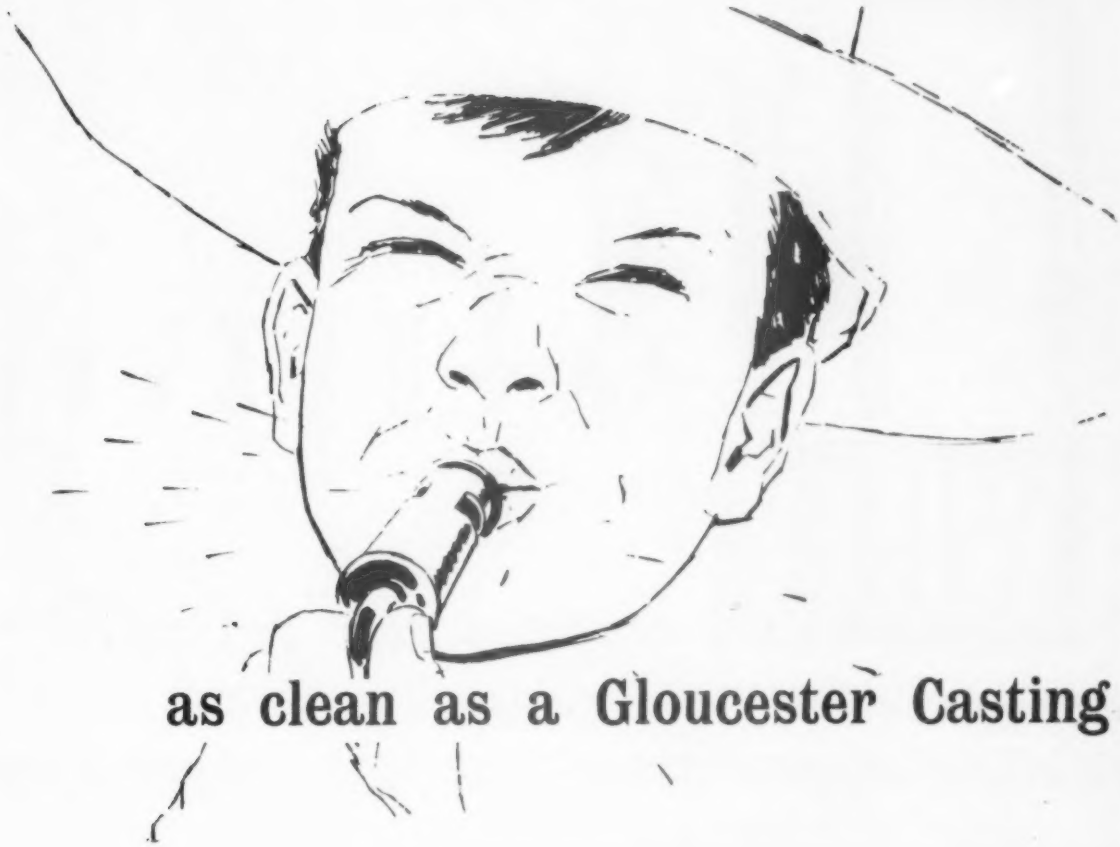

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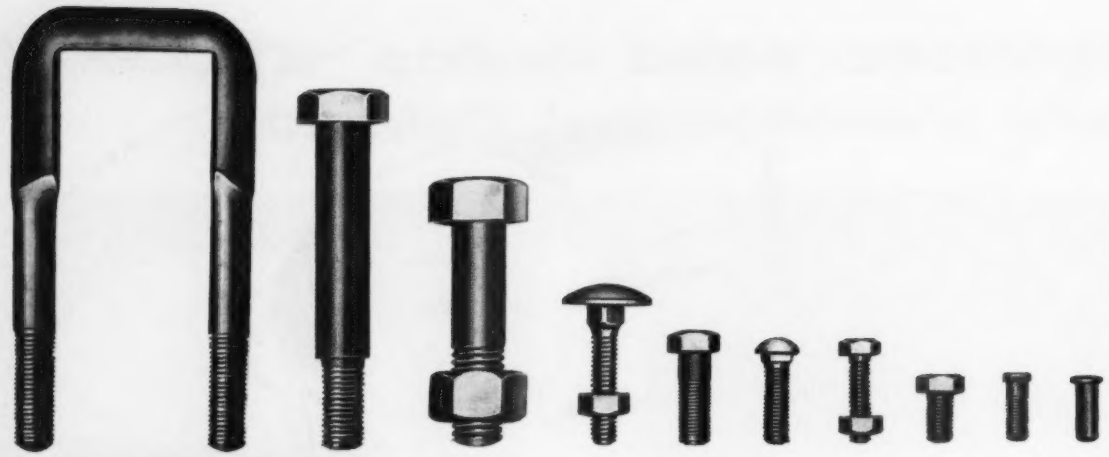

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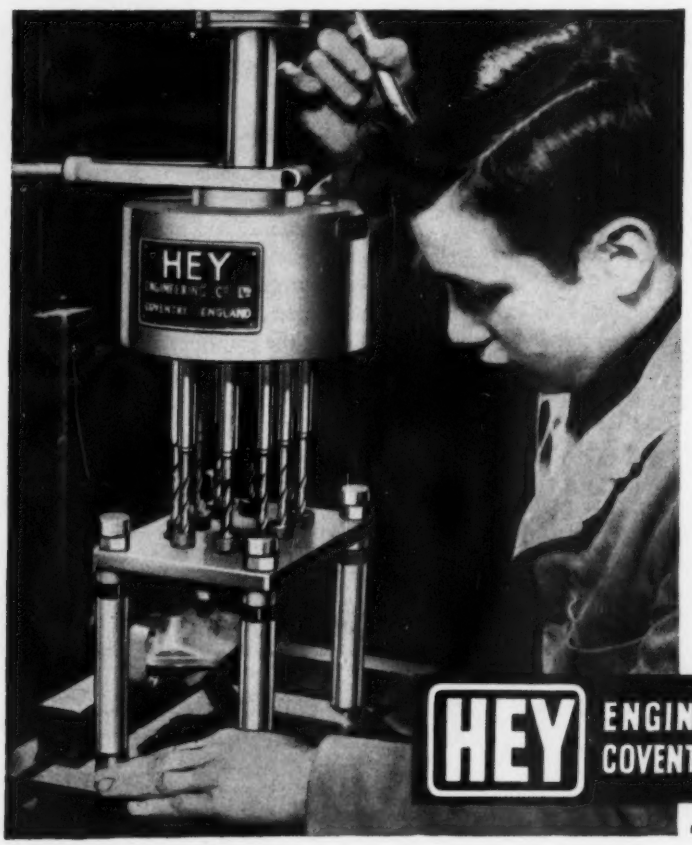

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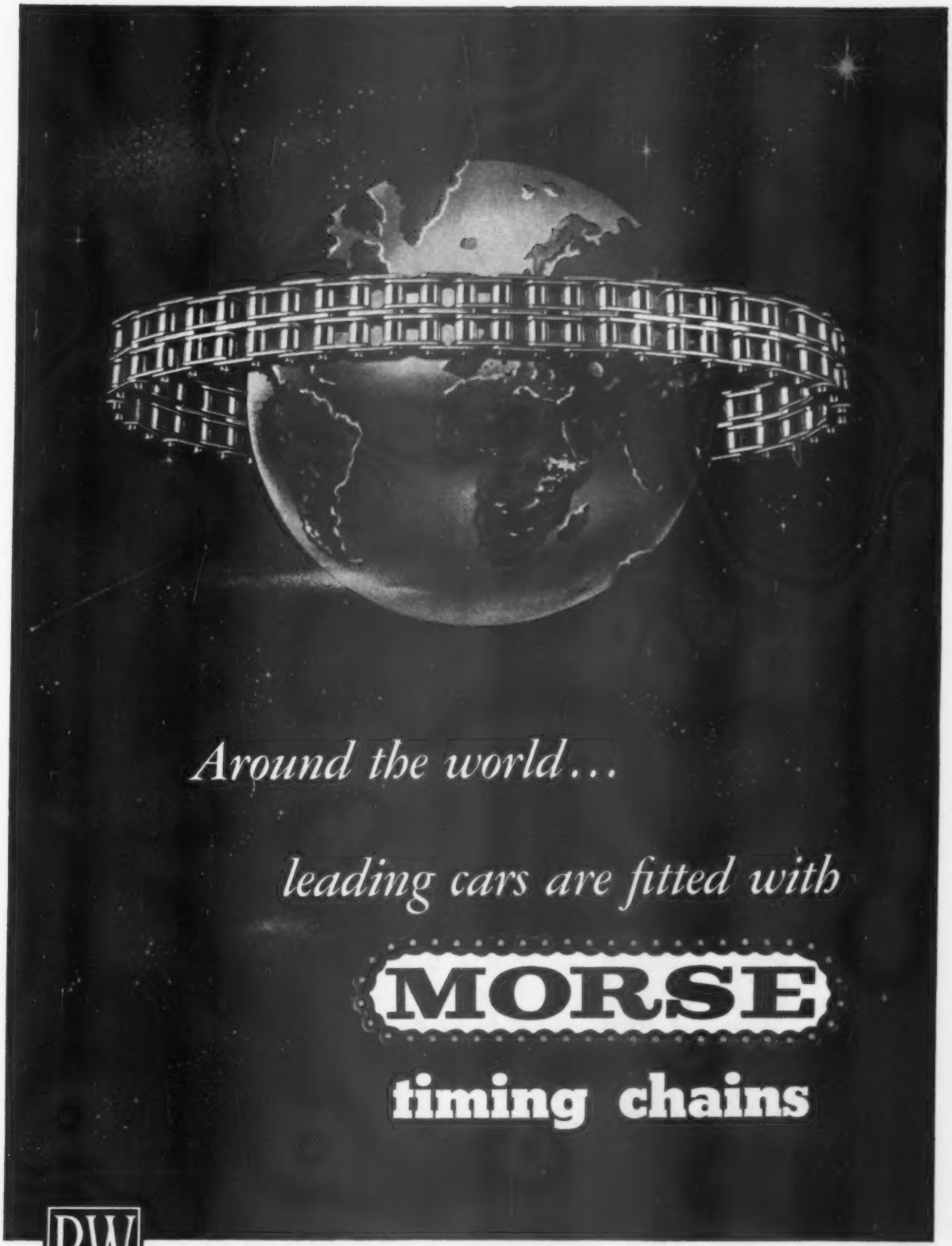

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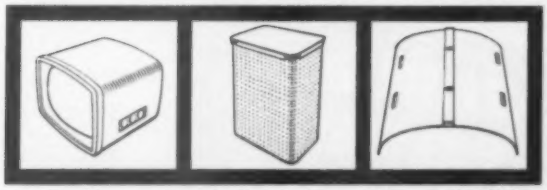

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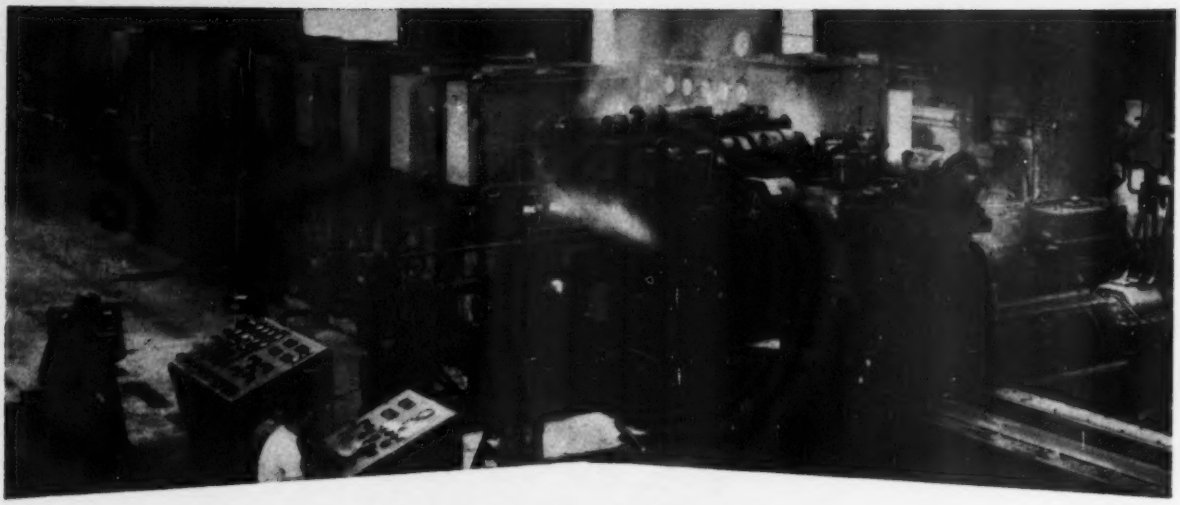

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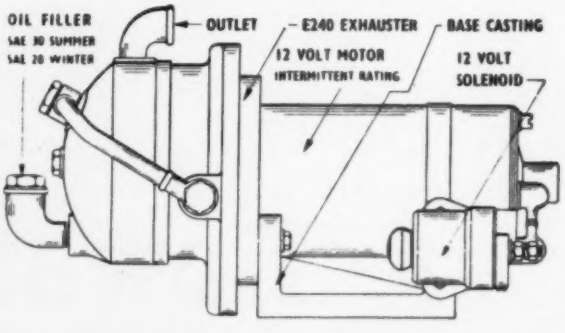

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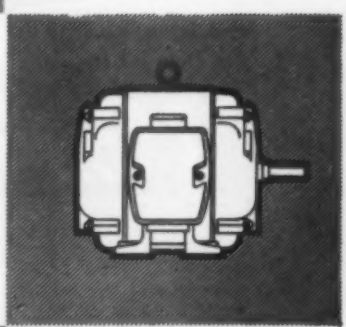

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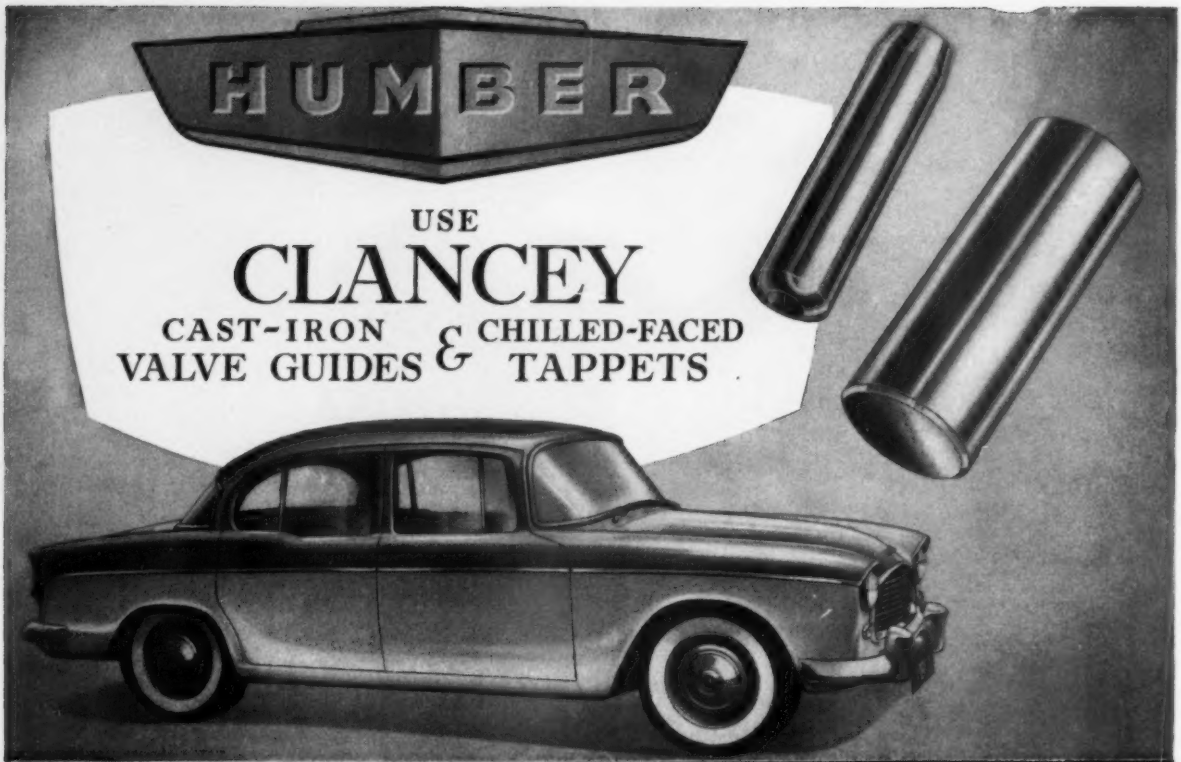

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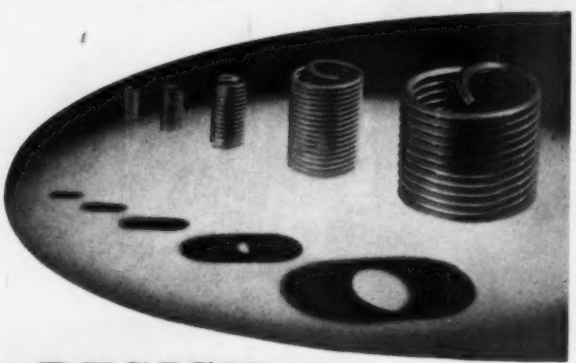

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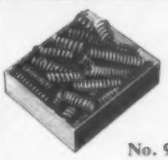

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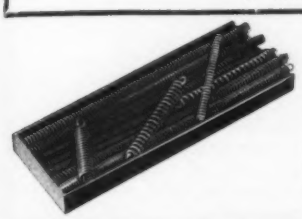

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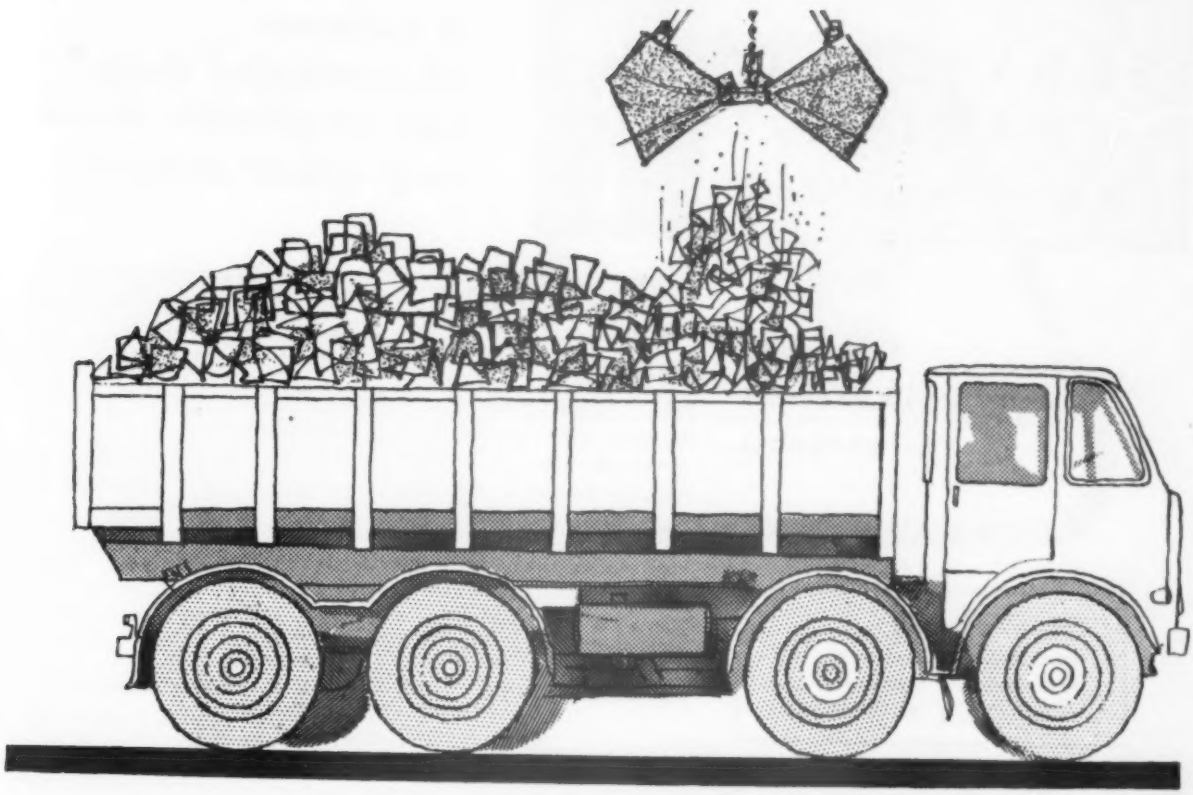

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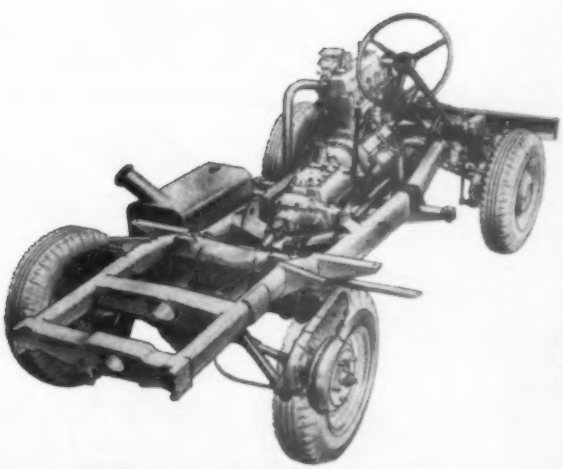

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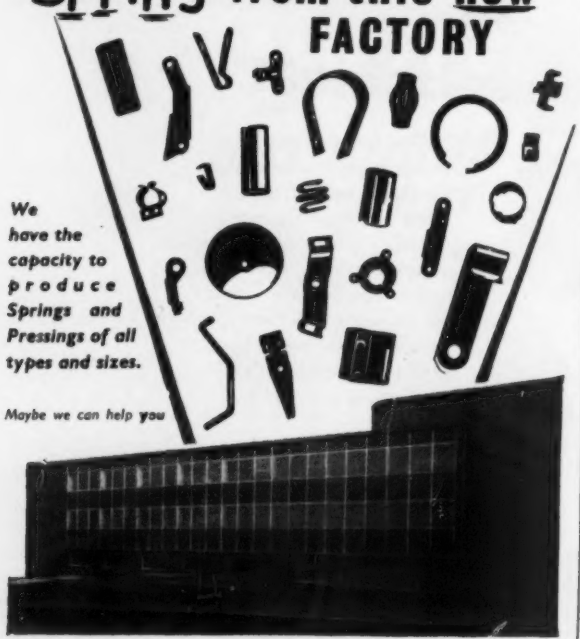

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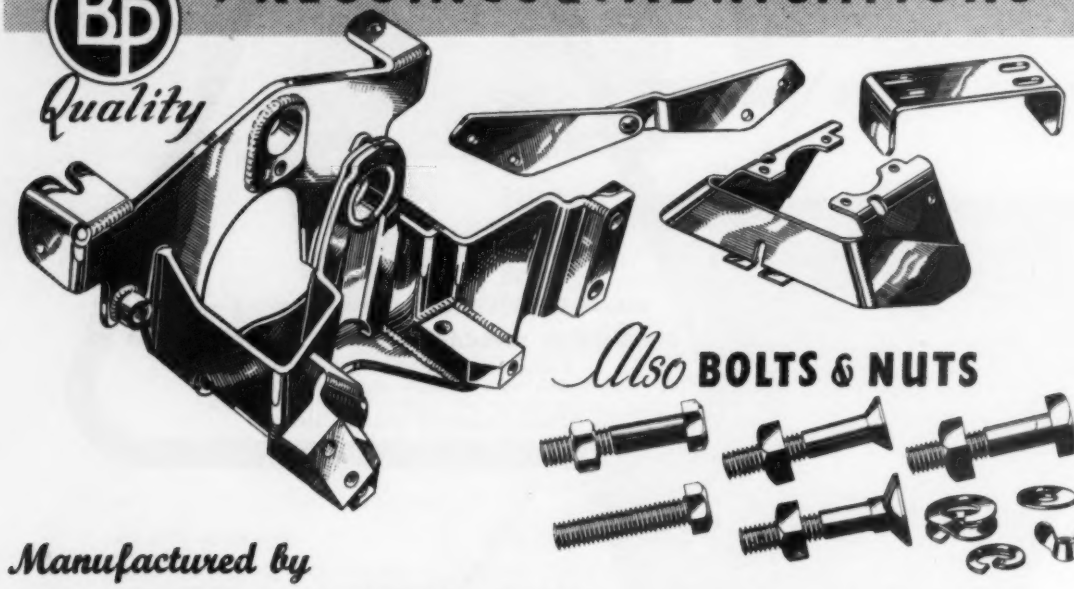

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Electrical Aids in Industry — *Data Sheet* **No. 3**

Induction Heating - 2

The broad principles involved in the use of induction heating for melting and processing metals have already been dealt with in this series (Data Sheet No. 2). In order to make a critical examination of its possibilities, however, the potential user should be aware of certain technical factors which must influence his decisions.

Induction heating, of course, demands the use of alternating current which is available from the public supply at a frequency of 50 cycles per second. Higher frequencies, however, are desirable for certain applications and can be obtained by means of the appropriate conversion equipment. Frequencies can therefore be considered in three categories:

Mains Frequency
(direct from mains)—50 c.p.s.

Medium Frequency
(machine generator)—50-10,000 c.p.s.

High Frequency
(electronic generator)—up to about 2,000,000 c.p.s.

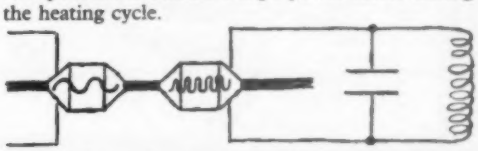
Mains Frequency

This needs no conversion equipment; it is particularly suitable for melting large pieces of scrap and, owing to the vigorous stirring forces produced, is excellent for alloy making. It has the merit of low initial cost compared with the high frequency method of melting, but is not so suitable for the production of high grade steel. Mains frequency induction heating is also useful for stress-relieving of welds in pipes and vessels, heating of chemical vessels, pipelines, injection moulding machines and press platens.

A typical example of the use of mains frequency is the coreless induction melting furnace which can be connected direct to the public 3-phase supply. Such a furnace rated at 120 kW, with a holding capacity of 2,240 lb., will give a throughput of 5,000 lb. per hour of hot cupola metal superheated from 1,350°C to 1,450°C.

Medium Frequency

Motor generators ranging from 10 kW to 1,500 kW or more at frequencies up to about 10,000 c.p.s. are widely used for heating for forging, melting from 100 lb. to 10 tons, hardening, annealing, etc. A bank of capacitors maintains a high power factor during the heating cycle.



Another form of generator for frequencies of 1 to 2 kc.p.s. and powers around 250 kW, useful for forge heating and melting high temperature aircraft alloys, is a 6-anode steel tank mercury arc inverter.

High Frequency

Metal hardening and metallurgical processing are best handled by high frequency induction (up to about 2,000,000 c.p.s.), particularly when a very thin case is required or when the section of the workpiece is too small to heat satisfactorily at medium frequency. These high frequencies are produced either by an electronic h.f. generator or a mercury-gap h.f. generator; high frequency induction can deal efficiently with such jobs as hardening lawnmower cylinders and cutters, bars and axle shafts.

The choice of frequency depends upon the metallurgical requirements and the size of the component to be treated. The following table gives the practical relationship between size and frequency, and may be used as a guide to the choice of generator, subject to metallurgical considerations.

Optimum Value

FREQUENCY C.P.S.	3,000	10,000	500,000	2,000,000
MIN. DEPTH OF HARDNESS POSSIBLE	.060 in.	.040 in.	.020 in.	.010 in.

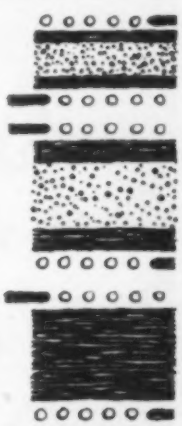
Practical Values

MIN. DEPTH HARDNESS EXPECTED	.150-.200 in.	.100-.150 in.	.030-.050 in.	.015-.030 in.
MIN. DIA. SURFACE HARDENING THIN CASE	2" & over	1" to 3"	½" to 2"	¼" to ½"
MIN. DIA. SURFACE HARDENING DEEP CASE	2" & over	2" & over	1" & over	not suitable
MIN. DIA. THROUGH HARDENING	1" & over	½" to 2"	¼" to ½"	not suitable

These are of course very approximate since they also depend on metallurgical considerations.

Power required for H.F. Induction Hardening

The high frequency power required per sq. in. of hardened surface depends upon the amount of metal behind the surface. Higher powers and shorter heating cycles are necessary for thin cases and when the thickness of metal behind the surface is small.


0.03" to 0.04" requires 1 sec. or less at 10 kW or more per sq. in.
0.1" to 0.2" with a large mass of metal behind the surface, requires 10-60 secs. at 2 kW per sq. in.
Through hardening requires 10-12 kWh per lb.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association. Excellent reference books (8/6, or 9/- post free) are available on electricity and productivity—"Induction & Dielectric Heating" is an example.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

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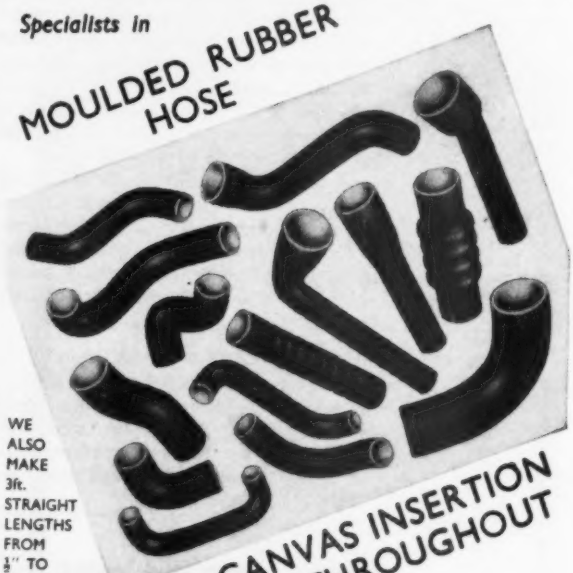

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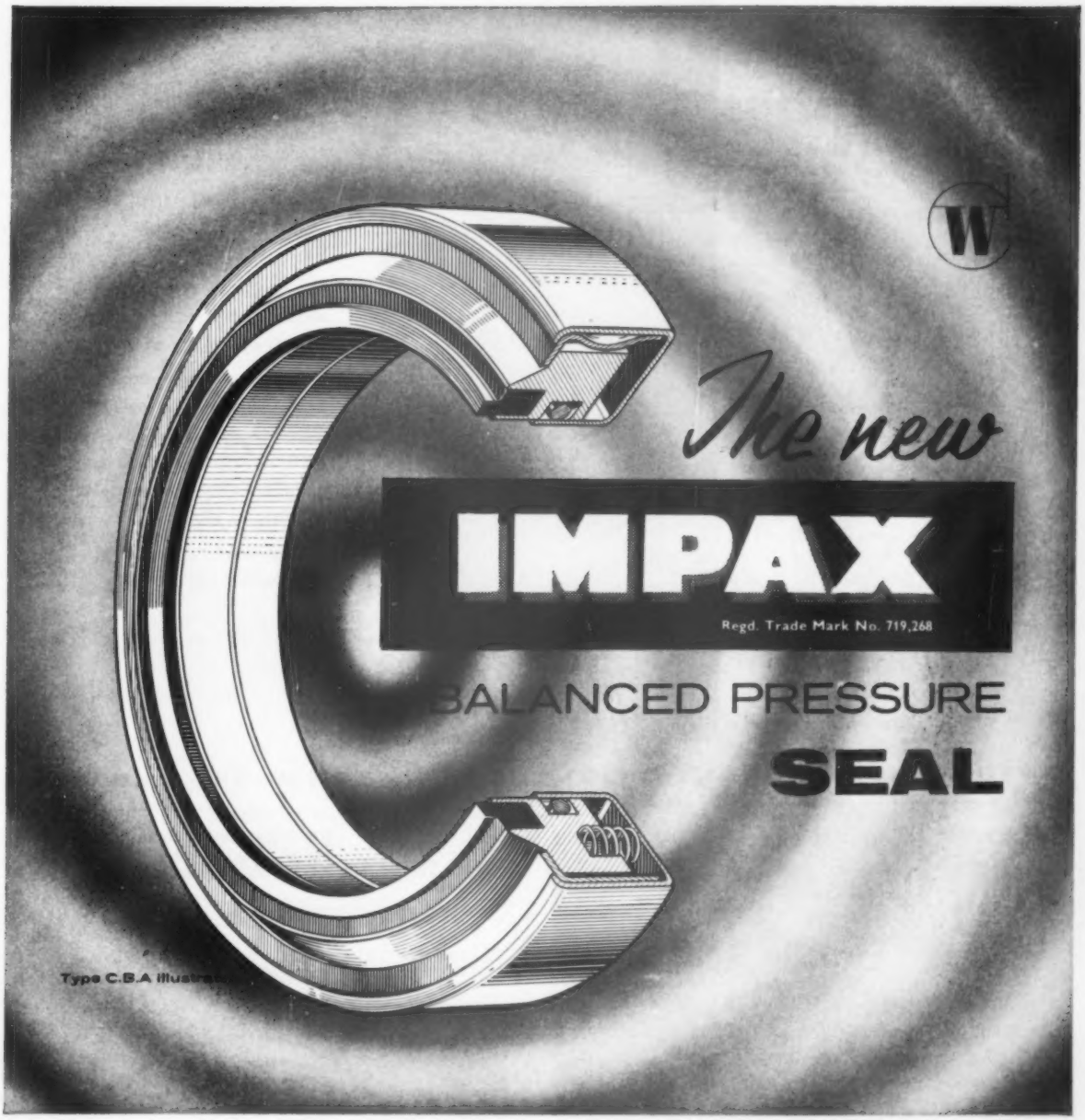

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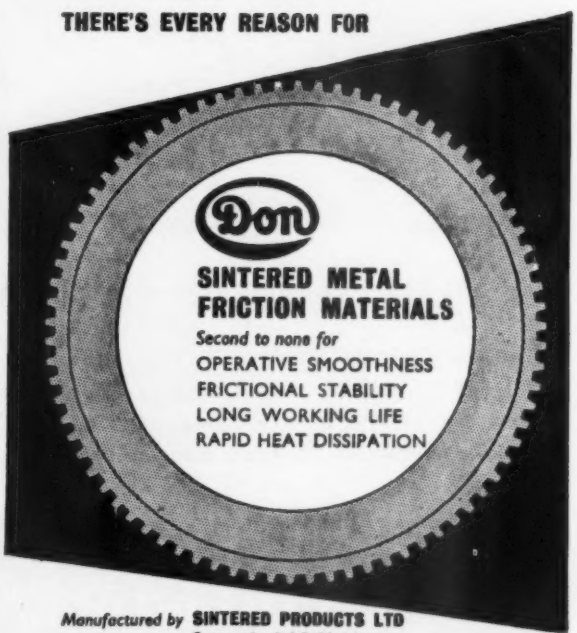

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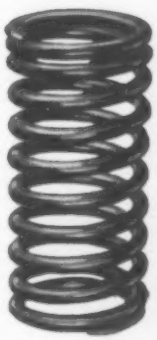

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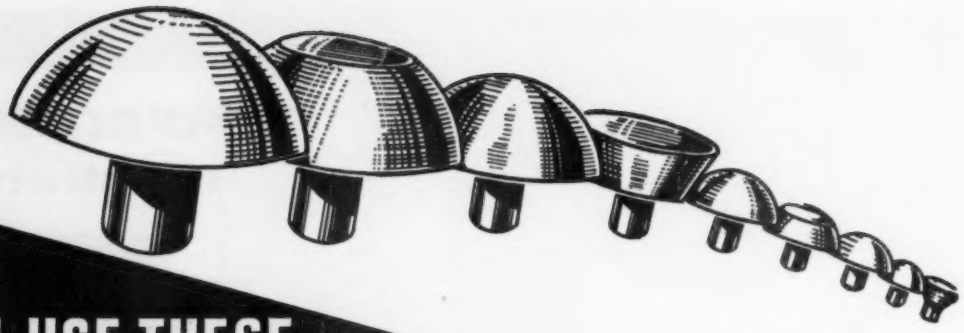

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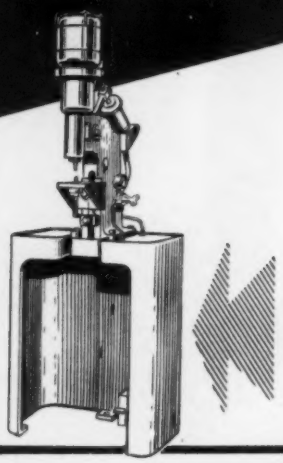

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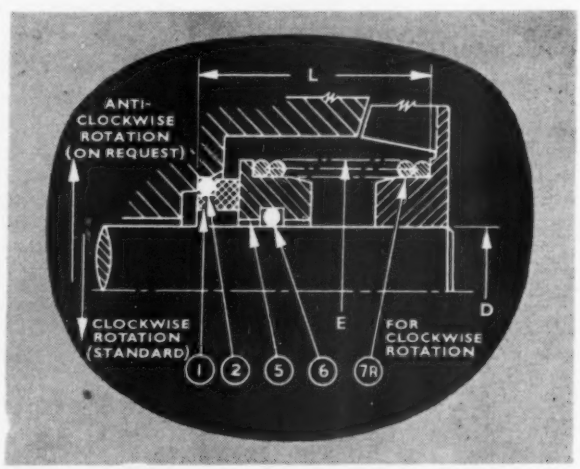

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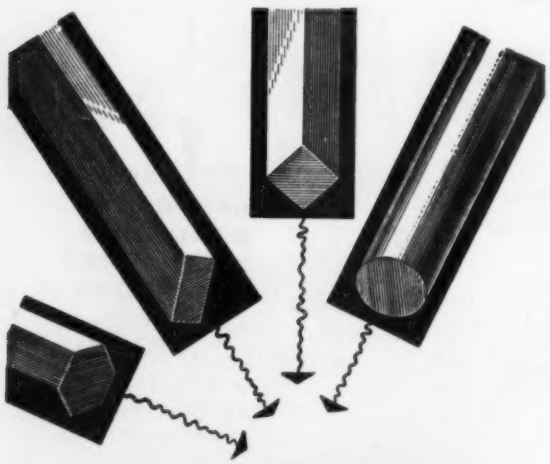

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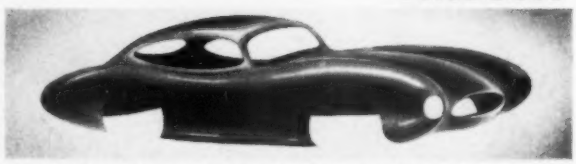

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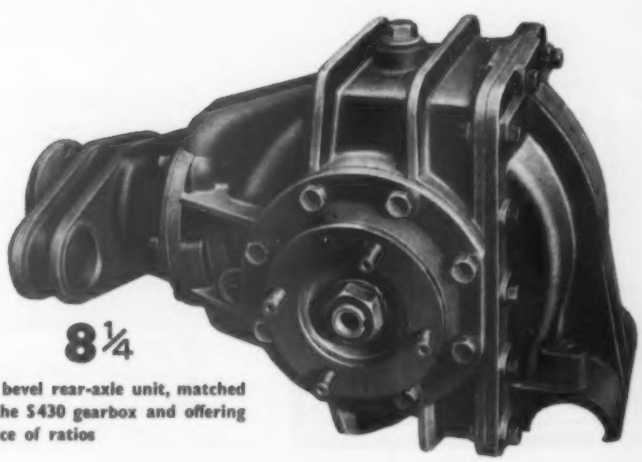

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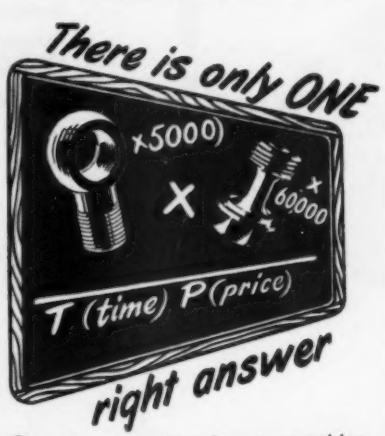

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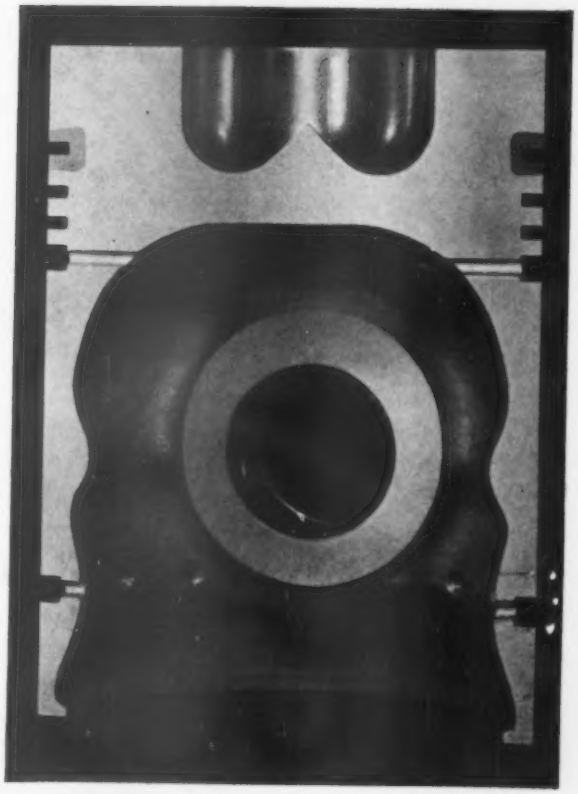

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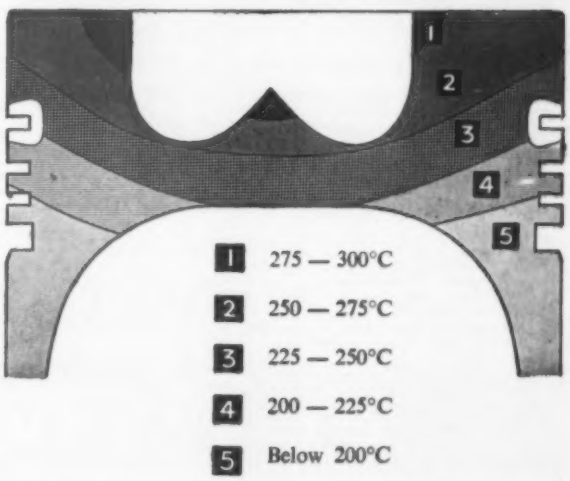

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	PAGE
Adamant Engineering Co. Ltd.	13
Aircraft-Marine Products (Gt. Britain) Ltd.	16
Air Trainers Link Ltd.	90
Albany Aero Accessories Ltd.	108
Aluminium Bronze Co. Ltd.	82
Amal Ltd.	102
Angus, George, & Co. Ltd.	32
Archdale, James, & Co. Ltd.	3
Armstrong Whitworth & Co. (Pneumatic Tools) Ltd.	58
Atlas Copco AB	Cover ii
Automotive Products Co. Ltd.	5, 6, 7, 8
Barber & Colman Ltd.	84
Birfield Industries Ltd.	11, 41, 49, 75
Birmetals Ltd.	46
Booth, James, & Co. Ltd.	76
Borg Warner Ltd. (Morse Chain Div.)	89
Bound Brook Bearings Ltd.	11
Bowaters Sales Co. Ltd.	91
British Oxygen Co. Ltd., The	52
British Petroleum Co. Ltd., The	4
British Piston Ring Co. Ltd., The	70
British Timken Ltd.	Cover i
Brook Motors Ltd.	93
Broom & Wade Ltd.	36
Brown, David, Corporation (Sales) Ltd., The	109
Bury Felt Mfg. Co.	9
Cape Asbestos Co. Ltd., The	22, 23
Cashmore, John, Ltd.	Cover iv
Castings Ltd.	67
C.A.V. Ltd.	40
CIBA (A.R.L.) Ltd.	35
Clancey, G., Ltd.	94
Clarkes (Redditch) Ltd.	98
Clayton Dewandre Co. Ltd.	Cover iii
Coopers Mechanical Joints Ltd.	108
Copper & Asbestos Washer Co. Ltd.	96
Cossor Instruments Ltd.	56
Cross Mfg. Co. (1938) Ltd.	94
Dartmouth Auto Castings Ltd.	62
Delaney Gallay Ltd.	69
Deloro Stellite Ltd.	86
Desoutter Bros. Ltd.	10
Dowty Seals Ltd.	64
Drummond - Asquith (Sales) Ltd.	18, 19
Dunford & Elliott (Sheffield) Ltd.	108
Du-Pont Co. (United Kingdom) Ltd.	15
Eaton Axles Ltd.	53
Edwards, F. J., Ltd.	110
Electrical Development Association	101
Eyre Smelting Co. Ltd., The	96
Fairman Precision Tools & Products Ltd.	92
Feeny & Johnson Ltd.	92
Feltham, Walter H., & Sons Ltd.	110
Ferodo Ltd.	30, 31
Firth-Vickers Stainless Steels Ltd.	65
Flexibox Ltd.	107
Fry's Metal Foundries Ltd.	26
Fuller, Horsey, Sons & Cassell	86
General Electric Co. Ltd., The	14, 60
Girling Ltd.	66
Gloucester Foundry Ltd.	87
Goulder, J., & Sons Ltd.	112
Habershon, J. J., & Sons Ltd.	92
Hardy Spicer Ltd.	49
Herbert, Alfred, Ltd.	25, 27
Hermetic Rubber Co. Ltd.	102
Hey Engineering Co. Ltd.	88
High Precision Equipment Ltd.	28
Hoffmann Manufacturing Co. Ltd., The	73
Holroyd, John, & Co. Ltd.	79
Holset Engineering Co. Ltd.	99
I.C.I. (General Chemicals, Heat Treatment) Ltd.	38
I.C.I. (Maranyl) Ltd.	77
Ilford Ltd.	85
Jackson, H., Ltd.	61
Jenks Bros. Ltd.	104
John Bull Rubber	80
Kirkstall Forge Eng. Ltd.	17
Lapointe Machine Tool Co. Ltd., The	20
Lead Development Association	100
Long Meadow Felt Co. Ltd.	44
Marsden, Samuel, & Son Ltd.	110
Marston Excelsior Ltd.	100
M.C.L. & Repetition Ltd.	110
Mek-Elek Engineering Ltd.	110
Metalastik Ltd.	29
Metropolitan Plastics Ltd.	33
Metropolitan-Vickers Electrical Co. Ltd.	42, 43
Midland Motor Cylinder Co. Ltd., The	63
Moss Gear Co. Ltd.	90
Newall, A. P., & Co. Ltd.	2
Philidas Div. of Whitehouse Industries Ltd.	47
Pioneer Oilsealing & Moulding Co. Ltd.	1
Pitman, Sir Isaac, & Sons Ltd.	96
Pollard Bearings Ltd.	45
Priest, B., & Sons Ltd.	100
Ransome & Marles Bearing Co. Ltd.	24, 54, 55
Renold Chains Ltd.	59
Rockwell Machine Tool Co. Ltd.	50, 98
Rubber Bonders Ltd.	48
S. & D. Rivet Co.	94
Sahlin Engineering Co. Ltd.	82
Salisbury Transmission Ltd.	41
Salter, Geo., & Co. Ltd.	12, 105
Sankey Green Wire Weaving Co. Ltd.	80
Sankey, Joseph, & Sons Ltd.	78
Schrader's, A., Son	21
Selson Machine Tool Co. Ltd., The	74
Sheffield Twist Drill & Steel Co. Ltd., The	51
Shell-Mex & B.P. Ltd.	107
Shotton Bros. Ltd.	75
Silentbloc Ltd.	39
Skefko Ball Bearing Co. Ltd.	72
Small & Parkes Ltd.	104
Solex (Gauges) Ltd.	57
Suffolk Iron Foundry (1920) Ltd.	104
Sykes, W. E., Ltd.	81
Terry, Herbert, & Sons Ltd.	95
Thomas, Richard, & Baldwins Ltd.	37
Thompson, John, Motor Pressings Ltd.	97
Turner Bros. Asbestos Co. Ltd.	102
Turner Machine Tools Ltd.	106
Udal, J. P., Ltd.	84
Vaughan, A. J. & Co. (Mitre Works) Ltd.	106
Wadkin Ltd.	34
Ward, Thos. W., Ltd.	83
Wellworthy Piston Rings Ltd.	111
Weston, Charles, & Co. Ltd.	103
Wild-Barfield Electric Furnaces Ltd.	68
Wiley, James, & Son Ltd.	88

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The vital necessity of brakes demands that only the best are good enough. Ensure that you have the best by fitting a 'Clayton Dewandre' vacuum or air pressure braking system to your trailers. Each system has variations in control and design to permit the most satisfactory installation, and, don't forget! — when considering your conversion, please supply full data regarding the existing brakes so that our appropriate recommendations may be made.

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AP 36

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